JPRS-UMS-87-004

20 APRIL 1987

USSR Report

MATERIALS SCIENCE AND METALLURGY

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USSR REPORT

MATERIALS SCIENCE AND METALLURGY

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FERROUS METALS

UDC 669.14.255:620.178.3

FATIGUE LIMIT OF Cr9WMoV-Sh STEEL UNDER CONTACT LOAD

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 7, Jul 86 (manuscript received 30 Sep 85) pp 105-106

[Article by Yu. A. Bashnin, V. A. Dzyuba, I. Ye. Blokhin, V. A. Nikolayev and V. V. Beletskiy, Kramatorsk Scientific Research and Design Technological Institute of Machine Building]

[Abstract] A new ledeburite steel with high surface hardness has been developed at the Kramatorsk Scientific Research and Design-Technological Institute of Machine Building for rollers to be used in a rolling mill of the Novolipetsk Metallurgical Combine. Unlike the existing 110Cr12MoV-Sh and Cr12Mo-Sh steels, this Cr9WMoV-Sh steel contains also 1.17% W, 0.076% Ti, 0.036% Ce, 0.03% Nb in addition to 1.34% C, 8.0% Cr, 1.07% Mo, 0.40% V, 0.48% Mn, 0.27% Si, 0.018% P and 0.008% S. Roller specimens of this steel and of the other two, for comparison, were tested for fatigue under a cyclically varying frictional contact load in a 3-roller machine built at the Institute of Structural Mechanics (UkSSR Academy of Sciences). Hollow rollers with 5 mm wide tracks, 35 mm outside diameter and 10 mm wall thickness, had been hardened to Rockwell C 60-61. Accelerated testing for endurance was done on a $25 \cdot 10^6$ cycles base only so as not to crush but only begin chipping the surface, with the contact stress varied over the 1176-2352 MPa range so as to simulate real load conditions in a 20-roller mill. The results indicate that this Cr9WMoV-Sh steel has a fatigue limit of 2058 MPa, a higher one than Cr12Mo-Sh steel (1960 MPa) and 110Cr12MoV-Sh steel (1793 MPa). References 3: all Russian.

2415/12955
CSO: 1842/254

UDC 620.179.14

A METHOD AND A DEVICE FOR THE NON-DESTRUCTIVE TESTING OF THE STRUCTURE OF PERMANENT MAGNETS

Sverdlovsk DEFEKTOSKOPIYA in Russian No 7, Jul 86
(manuscript received 16 Apr 85) pp 15-18

[Article by V. N. Soplyachenko, Saratov Polytechnical Institute]

[Abstract] A method and a device were developed for the non-destructive testing of the phase composition of YuNDKT alloys, which are used to manufacture permanent magnets. The testing method used was magnetic phase analysis, which made it possible to determine the relative volume of the paramagnetic γ-phase. This testing method entailed two basic complications: the impossibility of using conventional measuring techniques due to the fundamental non-uniformity of the magnetism when the magnets were magnetized in an open magnetic chain, and inconsistencies in the accuracy of the measurements caused by temperature factors. These complications were mitigated by measuring Parameter I at the precise moment when dI/dt = const. The measuring and testing device, the design of which is based on integrated microcircuits, consists of a transformer, an amplifier, a differentiator, a switch, two comparators, a peak detector, and a measuring device, the scale of which is graduated in percentage of γ-phase content. The device converts Parameter I into an electrical signal that is used to measure the γ-phase content and to sort the magnets into "suitable" and "non-suitable". In order to validate the testing method and device, permanent magnets of identical structure (24X24X60 mm made from YuNDK35T56 alloy) were subjected to thermo-magnetic treatment entailing homogenization at 1240±10°C for one to 30 minutes, cooling in a magnetic field down to 815±5°C for 10 minutes, followed by 12 hours of tempering with a gradual reduction in temperature from 675 to 550°C. After this treatment, the magnetic characteristics of the specimens were measured and the γ-phase content determined using microanalysis. The magnetic field induction measured near the surfact of the specimens during normalization was found to depend on the nnumber of γ-phases and is directly linked to the level of magnetic properties. The method and measuring device discussed can be used to automate testing and can be easily incorporated into existing manufacturing processes in order to detect defective magnets in the early stages of production. References 4: all Russian.

13050/12955
CSO: 1842/266

UDC 620.179.14

THE SENSITIVITY OF AN EDDY-CURRENT TRANSDUCER WITH A ROTATING MAGNETIC FIELD TO THE PARAMETERS OF A CYLINDRICAL OBJECT

Sverdlovsk DEFEKTOSKOPIYA in Russian No 7, Jul 86
(manuscript received 28 May 85) pp 19-24

[Article by P. A. Ovsyannikov, Scientific Research Institute of Electronic Introscopy, Tomsk]

[Abstract] The sensitivity of an eddy-current transducer with a rotating magnetic field to changes in the radium, electrical conductivity, and relative magnetic permeability of a cylindrical object were analyzed. Five different values were used for magnetic permeability. A generalized parameter $\tilde{\underline{x}}$ was used when analyzing the sensitivity to the radius and magnetic permeability, and a variable $\tilde{\underline{x}}$ was used when analyzing electrical conductivity. The results of the analysis were presented in the form of hodographs. The hodograph constructed for sensitivity to the radius showed that the true component of this sensitivity measurement was larger than the others for a weakly magnetized cylinder and achieved its maximum value when $\tilde{\underline{x}}$ = 2-2.5. The imaginary component grew as magnetic permeability increased when values for the generalized parameter $\tilde{\underline{x}}$ were small, and reached its maximum value when $\tilde{\underline{x}}$ 0. The modulus of sensitivity to electrical conductivity was greater for a weakly magnetized cylinder than for a non-magnetized cylinder for most values of variable $\tilde{\underline{x}}$, and decreased as magnetic permeability increased. The modulus of sensitivity to relative magnetic permeability grew as relative magnetic permeability decreased, if $\tilde{\underline{x}}$ was less than 2, and reached its maximum when magnetic permeability equaled zero and $\tilde{\underline{x}}$ 0. The different values for magnetic permeability had optimal values for $\tilde{\underline{x}}$ at which both the modulus of sensitivity to electrical conductivity and the modulus of sensitivity to relative magnetic permeability achieved maximum values. On the basis of this analysis, it was determined that: 1) when separately testing the diameter and electrical conductivity of non-magnetic cylinders, the values for the generalized parameter should be high, and 2) the values for the generalized parameter should be low when separately testing the diameter, electrical conductivity, and relative magnetic permeability of ferromagnetic cylinders. References 4: all Russian.

13050/12955
CSO: 1842/266

UDC 620.179.14

USING THE DIFFERENTIAL EDDY-CURRENT METHOD TO MEASURE THE RADIUS AND ELECTRICAL CONDUCTIVITY OF CYLINDRICAL OBJECTS

Sverdlovsk DEFEKTOSKOPIYA in Russian No 7, Jul 86
(manuscript received 4 Jun 85) pp 24-31

[Article by V. P. Sebko, Kharkhov Polytechnical Institute imeni V. I. Lenin]

[Abstract] The feasability of using the differential eddy-current method to simultaneously test the radius and electrical conductivity of cylindrical non-magnetic objects was studied. The approach used was based on the expansion of the universal functions of the non-dimensional electrical parameters of transformer eddy-current transducers vs. the generalized parameter for the properties of the object being studied into a Taylor series. These functions are close to a fixed working point. The differential circuit used to measure the radius and electrical conductivity comprised two identical transducers and two compensating coils. One of the transducers served as the working transducer and contained the object being studied, while the other transducer served as the compensating transducer and contained a standard specimen. The circuit was prepared for the testing procedure by placing a standard specimen made of copper in the compensating transducer and a specimen with characteristics nearly identical to those of the standard specimen in the working transducer, and then balancing the system. The specimens to be tested were then placed in the working transducer. When there was very little difference between the characteristics of the standard specimens and the specimens being studied, the results of measuring the radius and electrical conductivity with the differential method were very close to the results of measurements of these parameters taken by other testing devices. However, the variance in the measurements taken using the differential method increased when there were greater differences between the characteristics of the standard and experimental specimens. Mathematical techniques for minimizing this variance are described. References 9: all Russian.

13050/12955
CSO: 1842/266

UDC 621.376.53

A STABILIZED TRANSISTOR TRANSDUCER FOR THE SIRENA-1 SELF-PROPELLED X-RAY FLAW DETECTOR

Sverdlovsk DEFEKTOSKOPIYA in Russian No 7, Jul 86
(manuscript received 26 Aug 85) pp 36-39

[Article by S. B. Krasilnikov, A. L. Kristalinskiy, L. N. Lozovoy, S. N. Markov and Ye. I. Sindalovskiy, Leningrad Burevestnik Scientific Production Association]

[Abstract] An improved stabilized transducer for use in the SIRENA-1 flaw detector and MIRA-2D and NORA radiators was developed. Its technical specifications are: rated voltage of the power source - 24 V; full range of power source voltage - 14-28 V; transformer's output voltage - 10-12 KV; rated X-ray pulse frequency for the MIRA-2D - 8.5 Hz; size - 370X60X120 mm; weight - 3.3 kg. The operating principle of the transducer consists in the periodic accumulation of the energy from a low-voltage power supply in the form of the energy in the magnetic field of the transformer core, the subsequent rapid interruption of the current of the primary winding by a high-voltage breaker, and the charging of the storage capacitor of the X-ray device with a pulse of inverse voltage generated by the secondary winding of the same transformer. The performance of this transducer exceeds that of existing transducers. It can be used with many different types of direct current power supplies, it loses little energy in the power and auxiliary circuits, it is highly efficient, and it maintains greater stability in the frequency of X-ray pulses when the voltage of the primary power supply fluctuates. References 4: all Russian.

13050/12955
CSO: 1842/266

UDC 620.179.15

CERTAIN FEATURES OF IMAGE FORMATION DURING X-RAY PULSE IRRADIATION

Sverdlovsk DEFEKTOSKOPIYA in Russian No 7, Jul 86
(manuscript received 28 May 85; in final version 2 Jan 86) pp 43-50

[Article by A. A. Altukhov, Ye. A. Gusev and V. V. Lomonosov, Introscopy, Moscow Scientific Research Institute]

[Abstract] The kinetics of image formation during pulse and stationary X-ray irradiation on X-ray film, in luminophores, and in electro-radiographic plates were studied and compared. It was determined that, at specific radiation levels, pulse durations, and periodic pulse repetitions, higher-quality images can be obtained using pulse irradiation. References 5: 4 Russian, 1 Western.

13050/12955
CSO: 1842/266

UDC 620.179.16

AN INSTRUMENT FOR MEASURING THE PARAMETERS OF THE ELECTRONIC BLOCK OF ULTRASOUND FLAW DETECTORS

Sverdlovsk DEFEKTOSKOPIYA in Russian No 7, Jul 86
(manuscript received 4 Jul 85) pp 84-85

[Article by V. G. Perlatov, V. Ye. Antipin and B. L. Zubatyy, VNIINK (possibly All-Union Scientific Research Institute of Scientific Design Kishinev]

[Abstract] The GSP UP-10PU, designed to measure the parameters of the electronic blocks of ultrasound flaw detectors during series production and operation, has been developed. It measures the following parameters: the maximum sensitivity and non-linearity of a receiver's amplitude characteristic; the error in measuring the signal amplitude rations at a receiver's input; the depth, delay, and duration of the temporary sensitivity adjustment; the error in the depth guage; the tuning error, temporary instability, and high-speed operation of the threshold indicator; the level of noise cutoff; the ultrasonic velocity range of the materials being tested; and the time and spectral parameters of the flaw detectors echo pulses. The instrument processes signals in the form of radio pulses with regulated amplitudes and time and frequency parameters. It also amplifies and temporarily selects signals fed through its input. It consists of a functional generator of radio pulses and a amplifying and selecting device and generates the radio pulses at frequencies of 0.625; 1.25; 2.5; 5.0; and 10.0 MHz. Its technical specifications are: working frequency range - 0.1 to 30 MHz; voltage amplitude of the radio pulses with a load of 50 ohms - not less than 5 volts; duration of radio pulses - 2 to 100 microseconds; delay of radio pulses - 3 to 9000 microseconds; duration of the selector zone - 2 to 400 microseconds; delay of the selector zone - 1 to 6000 microseconds; range of radio pulse amplitude attenuation - 0 to 89 db; discreteness of radio pulse amplitude attenuation - 0.1 db; amplification coefficient - not less than 50 db; amplifier input parameters - resistance - not less than 30 kohms, capacity - not more than 20 pf; power consumption - not more than 80 Va; weight - not more than 20 kg; size - 490X500X170 mm. References 4: all Russian.

13050/12955
CSO: 1842/266

UDC 539.2:620.193:678.067

INFLUENCE OF LONG TERM ATMOSPHERIC AGING ON PROPERTIES AND STRUCTURES OF CARBON-REINFORCED PLASTIC

Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 4, Jul-Aug 86 (manuscript received 9 Nov 85) pp 637-642

[Article by O. V. Startsev, Yu. M. Vapirov, I. S. Deyev, V. A. Yartsev, V. V. Krivonos, Ye. A. Mitrofanova and M. A. Chubarova]

[Abstract] This article is a report which was presented at the Sixth All-Union Conference on Mechanics of Polymer and Composite Materials, Riga, November, 1986. Studies are presented of the changes in mechanical properties, thermal expansion, thermal stability and microstructure of a unidirectional carbon-reinforced plastic after 11 years of aging in a hot, humid area near Batumi. The unidirectional carbon-reinforced plastic studied is based on an epoxy triphenol binder, reinforced with VEN-210 carbon fiber 57± 1% by volume. Linear dilatometry confirms weakening of the adhesion interaction between the filler and binder, resulting in an increase in deformability of aged specimens. Photomicrographs reveal structural changes in the body of the matrix and at the polymer-fiber interface, increases in microheterogeneity of the material and delamination of individual matrix sections from the fiber. The results reveal the molecular mechanism of long-term atmospheric aging of carbon-reinforced plastic in a moist subtropical climate. References 8: all Russian.

6508/12955
CSO: 1842/8

UDC 621.774.21

A LASER DEVICE FOR MEASURING THE SPEED OF HOT ROLLED METAL

Moscow STAL in Russian No 8, Aug 86, pp 65-68

[Article by V. F. Artamonov, P. Ya. Belousov, Yu. N. Dubnishchev, V. A. Zhmud and A. A. Stolpovskiy, Novosibirsk Metallurgical Plant and the Automation and Electrometry Institute, Siberian Department, USSR Academy of Sciences]

[Abstract] A laser device for measuring the speed of hot rolled metal has been developed. An operating prototype of this device was installed on a reducing mill for the remote measurement of the speed and length of hot pipe. The device has the following technical specifications: range of measurable speed -- 0.5 - 6.0 m/s; temperature of the rolled metal -- 1000°C; depth of optical scanning field -- ± 30 mm; speed measurement error during an averaging time of 0.1 s -- 0.2%; distance to pipe surface -- 1475 ± 30 mm; pipe length measurement error -- 0.2%. The device is equipped with a digital display of speed and length; digital output in binary-decimal code (TTL level)

and output of analog voltage proportional to the speed in the frequency band of 100 Hz. The design of the meter is based on laser Doppler anemometry. The meter contains an optical sensor on an adjustable stand and an electric signla processing block based on a KAMAR design. References 2: both Russian.

13050/12955
CSO: 1842/269

UDC 539.612:546.72

SPREADING OF COPPER OVER NIOBIUM ALLOYS

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 7, Jul 86 (manuscript received 21 Nov 85) p 148

[Article by A. A. Shevchenok, Yu. A. Minayev and N. T. Konovalov, Moscow Steel and Alloys Institute]

[Abstract] Spreading of liquid copper over solid niobium alloys was studied, for the purpose of controlling the copper impregnation and coating process. Cylindrical specimens of copper weighing 0.366 g each were melted in a TVV-4 tubular high-temperature vacuum furnace under a residual pressure of 10^{-3} Pa at a temperature controlled within $\pm 10°C$. Molten copper was then poured on plates of Nb-Zr alloys at 1100°C, whereupon that temperature was maintained for at least 0.5 min and up to 30 min. Specimens subsequently cut through the contact surface were examined under a "Neophot-2" optical microscope and a JSM-25S scanning electron microscope as well as in a JXA-5 x-ray phase and structure microanalyzer. The results indicate formation of a thin film with aureole spreading from the liquid copper droplet on the alloy surface and subsequent formation at 1100°C of a Cu-Nb-Zr system consisting of $ZrCu_4$ solid solution with 1.66 wt.% liquid α- Cu and 2 wt.% β-Nb. Spreading of copper over a Nb-Zr alloy is, accordingly, attended by its layerwise diffusion into niobium and chemical reaction with zirconium. References 5: 4 Russian, 1 Western.

2415/12955
CSO: 1842/254

UDC 669.15:621.785.5

PROPERTIES OF ZrC COATINGS ON TOOL STEELS

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 7, Jul 86 (manuscript received 4 Mar 86) pp 101-104

[Article by V. F. Loskutov and V. G. Khizhnyak, Kiev Polytechnic Institute]

[Abstract] A study of ZrC coatings on tool steels U10A, Cr15 (for ball bearings), 9CrSi, CrWMn, Cr12Mo was made, such coating having been deposited under reduced pressure at temperatures of 1223,1273,1323,1373 K and let build up for 0.5-2-4-6 h at each temperature. The coating material was produced from commercially pure Zr powder and charcoal with CCl_4. Specimens of those steels with coating were tested for hardness and their microstructure was examined under a microscope as well as by layerwise x-ray phase and microspectral analysis. The coatings were found to contain not only ZrC but also elements forming part of the steel, particularly 2.6-6.4% Fe and 1.0-2.3% Cr, with the Zr content varying from 83.8-86.9% at the outer surface to 81.2-86.0% at the inner surface and to less than 0.1% immediately below the ZrC-steel interface. Coatings were found to contain less C, Fe and more Zr, Cr when deposited at higher temperatures on the same steel or on more heavily alloyed steels at the same temperature, the Cr concentration being always maximum in the transition zone under the coating and 4.0-20.0 μm thick depending on the deposition temperature and time as well as on the steel composition. Steels heat treated by quenching and tempering to RC 60 hardness were tested for abrasion by B_4C_3 powder and for corrosion in water and in 3% NaCl solution, bare and with 11.0-14.5 μm thick ZrC coating. A coating was found to increase both wear and corrosion resistance of these steels appreciably but to various degrees, making Cr12Mo steel much more corrosion-resistant than U10A steel and making U10A steel more wear-resistant than Cr12Mo steel. Dies and punches made of these steels with ZrC coating were tested in manufacturing operations on various carbon steels and their performance found to be greatly improved by it. References 3: all Russian.

2415/12955
CSO: 1842/254

UDC 541.64:539.2

COMPARATIVE ANALYSIS OF DYNAMIC MECHANICAL PROPERTIES OF REINFORCED POLYMER FIBERS

Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 4, Jul-Aug 86 (manuscript received 24 Dec 85) pp 579-584

[Article by A. S. Badayev, I. I. Perepechko and V. Ye. Sorokin, Moscow Automechanical Institute; Voronezh Polytechnical Institute]

[Abstract] This article, presented at the Sixth All-Union Conference on the Mechanics of Polymer and Composite Materials, Riga, November, 1986, reports on a study of the dynamic mechanical properties of a number of polymer fibers, differing in chemical structure, over a broad temperature range. The specimens studied were elementary fibers 10 to 25 microns in diameter and 1 to 5 mm in length. Measurements were performed by free torsional oscillations on a specially developed torsional micropendulum permitting measurement of the dynamic shear modulus and mechanical loss angle tangent at 20-1000 K and 0.1-2.5 Hz. The low frequency shear wave velocity was computed from the direct results. The results indicate that β-relaxation in these objects is related to the development of inhibited rotation of phenylene groups. All thermally stable polymers show a characteristic intense α'-maximum of mechanical losses at $T_\alpha > T$, accompanied by a sharp increase in dynamic shear modulus, related to processes of structure formation. The results confirm the assumption, based on anomalously high apparent activation energy and width of the major relaxation maximum, of a high degree of cooperation in segmented motion in rigid-chain polymers. References 10: 6 Russian, 4 Western (2 in Russian translation).

6508/12955
CSO: 1842/8

UDC 678.686:541.67

EPOXY-ROLIVSAN THERMALLY STABLE BINDERS FOR REINFORCED PLASTICS

Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 4, Jul-Aug 86 (manuscript received 10 Jan 86) pp 590-594

[Article by B. A. Zaytsev, R. F. Kiseleva, S. L. Garkavi and L. M. Kalyuzhnaya, High Molecular Compounds Institute, USSR Academy of Sciences, Leningrad]

[Abstract] A new type of binder has been developed. The materials are called rolivsans, an acronym for reactive oligomers of the Institute of High Molecular Mass Compounds, Academy of Sciences. Rolivsans are liquid or low melting point unsaturated monomer-oligomer compositions which are chemically produced and cured by a polymerization-polycondensation method. Reinforced plastics based on polyrolivsans retain 60 to 75% of their initial strength at 250°C, and can be used for long periods of time at 250-300°C. However, the deformation, strength and adhesive properties of polyrolivsans are inferior to polyepoxy materials. This article studies various epoxy-rolivsan compositions, in an attempt to combine the superior properties of epoxy resins with the thermal stability of rolivsans. The new products have tensile strengths 10 to 40% better than rolivsans and thermal stability is markedly superior to epoxy materials. References 7: 4 Russian, 3 Western (in Russian translation).

6508/12955
CSO: 1842/8

UDC 539.376:678.067.5

NUMERICAL METHOD OF DETERMINING RHEOLOGICAL PARAMETERS OF COMPOSITES FROM TEST RESULTS

Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 4, Jul-Aug 86 (manuscript received 9 Dec 85) pp 605-609

[Article by D. A. Gavrilov and V. A. Markov, Mechanics Institute, Ukrainian Academy of Sciences, Kiev]

[Abstract] The purpose of this work was to develop a method for determining the parameters of an exponential fraction function based on creep test data which does not have the limitations of previous methods and is suitable for any time base of testing. The problem is reduced to finding the minimum of a function of a single variable. The capabilities of modern computers allows successful estimation of the parameters which must be determined. A flow chart is presented of a program for determination of the parameters of a fractional exponent function. Existing computer programs were used to perform test calculations, yielding results which agreed satisfactorily with previously published results. References 12: all Russian.

6508/12955
CSO: 1842/8

UDC 539.4:678.067

PREDICTING FATIGUE RESISTANCE CHARACTERISTICS OF CARBON-REINFORCED PLASTIC BASED ON CREEP AND LONG TERM STRENGTH TESTING

Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 4, Jul-Aug 86 (manuscript received 17 Dec 85) pp 711-715

[Article by Yu. V. Suvorova, A. M. Dumanskiy, V. B. Strekalov and I. M. Makhmutov, Machine Science Institute imeni A. A. Blagonravov, USSR Academy of Sciences, Moscow]

[Abstract] This article is a report which was presented at the Sixth All-Union Conference on Mechanics of Polymer and Composite Materials, Riga, November, 1986. Hereditary relationships can be used to predict the fatigue resistance characteristics of composite materials based on creep and long-term static load testing. Formulas are derived to describe the processes of creep and long-term strength. The studies indicate that a limited number of parameters determined by creep and long-term strength testing can indeed be used to predict the behavior of carbon-reinforced plastic under arbitrary loading conditions, including deformation curves, strength and durability, as well as the characteristics of fatigue resistance. Similar values of the parameters can be calculated from experimental data obtained by rapid loading. References 18: 16 Russian, 2 Western.

6508/12955
CSO: 1842/8

UDC 534.669.7

INFLUENCE OF TRANSIENT ZONES AT FIBER-MATRIX INTERFACE ON PROPAGATION OF CRACKS IN AN ALUMINUM-BORON COMPOSITE

Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 4, Jul-Aug 86 (manuscript received 23 Dec 85) pp 733-736

[Article by G. G. Maksimovich, A. V. Filipovskiy, V. A. Polovtsev, M. E. Chaplya, V. I. Mikheyev, I. V. Tarasenko and N. M. Gvozdyuk, Physical Mechanical Institute imeni G. V. Karpenko, Ukrainian Academy of Sciences, Lvov]

[Abstract] A study is presented of the influence of brittle transient zones on crack resistance and crack propagation in an aluminum-boron composite. Studies were performed on composites with a matrix of M40 aluminum alloy, strengthening phase boron fiber 140 μm in diameter, obtained by hot rolling in the direction of the fiber of preassembled packets of the components. Volumetric fiber content was 35%. The studies showed that the formation of transient zones in the process of high temperature holding influences the mechanism of crack propagation in aluminum-boron composites and thereby leads to an increase in crack resistance with a simultaneous decrease in

strength in the direction perpendicular to the fibers, while decreasing crack resistance in the direction parallel to the fibers. References 11: 9 Russian, 2 Western.

6508/12955
CSO: 1842/8

METAL QUALITY AND PRODUCTIVITY OF METAL INDUSTRY DISCUSSED BY EXPERTS

Moscow ZNANIYE-SILA in Russian No 8, Aug 86 pp inside cover - 3

[Interview with Sergey Pavlovich Antonov, doctor of technical sciences, chief of Metallurgy Administration, USSR State Committee for Science and Technology, and Professor B.V. Rozanov, doctor of technical sciences, chief scientific expert, All-Union Scientific Research Institute of Metallurgical Machines imeni A.I. Tselikov, by correspondent L. Maksimov of ZNANIYE-SILA, published under the rubric "Bringing Into Effect the Resolutions of the 27th Congress of the CPSU": "Metal = Quality of the Concept + Quality of the Industrial Process + Quality of the Equipment + Quality of Work"; date and place not specified; the first paragraph is a keynote epigraph; the second paragraph is an introduction]

[Text] In nonferrous metallurgy the output of rolled products should be increased by the year 1990 to 116-119 million metric tons without increasing the output of cast iron and with a substantial reduction of the consumption of coke... The output of converter steel and electric furnace steel should be increased by a factor of 1.3-1.4; the amount of steel processed by continuous casting should be increased by not less than a factor of 2 and the production of metal powders by not less than a factor of 3. Work should be expanded in the industrial introduction of processes for direct production of iron and essentially new metal materials. (From Basic Directions for the Economic and Social Development of USSR in 1986-1990 and the Period up to the Year 2000.)

Sergey Pavlovich Antonov, doctor of technical sciences, chief of the Metallurgy Administration, USSR State Committee for Science and Technology, says: "... A deficit of metal will become a reality with all the attendant grave consequences unless within 15 years scientists and industrial metallurgists, working hand in hand with machine-building industry (I emphasize this especially), improve the quality of metal--its use value--by a factor of 1.5." The problems of present-day metallurgy, the advanced technological processes and some types of new equipment are discussed with our correspondent L. Maksimov by S.P. Antonov and Professor B.V. Rozanov, doctor of technical sciences, Honored Activist of Science and Technology, and Laureate of the Lenin Prize and State Prize, who is a chief scientific expert of the All-Union Scientific Research Institute of Metallurgical Machines imeni A.I. Tselikov.

[Question] The first question is how much metal is needed by mankind today and is the metal industry capable of meeting our demands?

[S.P. Antonov] In the last few decades a very complex and, in a certain sense, critical situation has developed in the metal industry.

I will start with numbers which at first glance seem reassuring. Last year about a billion metric tons of steel was smelted in the world. It is expected that within 15 years--before the end of the century--the output of steel will double and approach 2 billion metric tons. I would like to note that the Soviet Union has attained a record level of steel output--over 150 million metric tons per year. This is more than has ever been smelted by any nation in one year, including the United States and Japan. New highly efficient industrial processes are being developed and broadly introduced, such as continuous casting, electron-beam melting and powder metallurgy.

The billion tons that have been produced is an impressive number, but let us look at it from a different point of view. The per capita production in the USSR is approximately 570 kilograms per year; in the United States and Japan this number is even somewhat higher. Proceeding from this level it is usually assumed that for meeting the current demand, an industrialized nation should produce at least 500 kilograms per capita annually.

Twenty years ago the worldwide per capita production was just 100 kilograms. By 1985 the number rose to 230. The progress is significant, but note that that is just half of what is required by the modern technological development!

It is expected that by the beginning of the next millennium the earth's population will reach some 6 billion people. This means that for a normal economic development, mankind will need 3 billion metric tons of steel and alloys. But even the most optimistic forecasts predict that just 2 billion tons will be melted. Unless emergency measures are taken immediately, the metal deficit will be immense.

The situation is aggravated by the fact that metallurgy today has to develop in a situation of continuous depletion of its raw material base. While 25 years ago the iron content in the ore in the USSR was about 45 percent, last year it dropped to 35 percent.

This is a natural tendency: The deposits that were developed initially were, of course, the richest and closest to the consumption sites. Now is the turn of poorer deposits. The second stage of the West-Siberian Metal Works, for example, is directed at the use of the Lisakovsk phosphate ores with about 35 percent iron content. Besides, this ore is situated 1800 km from the plant.

The introduction of relatively poorer ores inevitably raises metal costs, and this despite the fact that melting and processing technologies are being steadily improved.

Unfortunately, higher costs of metals are due not only to the lower grades of ores used.

For many years the designers of metal works did not consider environmental protection to be an important issue. As a result, we have the following situation. A metal works producing 10 million metric tons per year--the kind of plants that currently produce most of the cast iron and steel--discharges daily into the atmosphere 600 metric tons of dust, 227 metric tons of noxious sulfur compounds and 700 metric tons of carbon dioxide. To visualize what this means, one can mention that the atmospheric releases of a modern metal works is by an order of magnitude (!) larger than the effects of all volcanoes on earth.

The fine dust from metal works released from the tall stacks at a high altitude is carried over hundreds and even thousands of kilometers, intensifying the so-called greenhouse effect. At the same time it screens ultraviolet radiation. Direct measurements have shown that within the radius of 4 kilometers from a metal works the ultraviolet component of solar radiation is attenuated by one-third.

Until recently, this facet of the problem was not given sufficient attention. But we can no longer go on like that. The party and the government, in defining the current objectives, call for a drastic restructuring in the shortest possible time. And the restructuring will come at a cost. In Japan, for example, even today 20 percent of the cost of metal production is paid for environmental protection. And that despite the fact that in Japan these problems are easier to resolve: Most plants are on islands and surrounded by sea.

[Question] What are the ways of surmounting the metal deficit, and are there any ways to deal with the negative consequences?

[S.P. Antonov] The main way of dealing with the deficit of metal is improving its use value. If we succeed in increasing that value by a factor of 1.5, the 2 billion metric tons of steel expected to be produced by the year 2000 will be equivalent to the necessary 3 billion.

[Question] What does that mean?

[S.P. Antonov] The use value is a notion with various ramifications. I do not think that in this conversation we should seek to give strict scientific definitions. The situation would be easier to understand and visualize by giving a few examples.

Here is one. For decades, cast iron radiators have been used to heat apartments, offices and workshops--these are cumbersome and, frankly, not quite esthetically attractive heating units. In the next few years they are to be replaced by radiators of a basically new type, welded from sheet steel, and an automatic production line manufacturing about 400,000 radiators per year has been created to produce them. For heating, they are not inferior but

actually much superior to the old cast iron radiators. But they weigh 3.5 times less. One can say that in this case the use value of the metal is higher by a factor of 3.5.

Here is another example, which is simple and convincing. At Nizhniy-Tagil Metal Works an additional operation--hardening--has been introduced in the production of railroad rails. As a result, the service life of a rail has been increased by 70 percent. To put it differently, their use value has grown by a factor of 1.7.

[Question] But such rails probably also cost more. And yet we have been speaking of the importance of findings ways of reducing the production costs in the industry.

[S.P. Antonov] Usually, each improvement comes at a price. The question is, what price? Hardening increases the cost of a rail by just 10-20 percent. But since its durability is increased by 70 percent, the cost to the consumer is reduced and not increased.

[Question] So the use value of the metal, Sergey Pavlovich, is largely determined by its quality?

[S.P. Antonov] Yes. And I think that any progress in any area must be accompanied by a quality improvement--otherwise, there is no progress. It is another matter that until recently attention has been focused in metallurgy on extensive ways of development--increasing production outputs. Now this potential has been largely exhausted. There remains another way--intensifying production and improving product quality, which depends on the quality of concepts, industrial processes and equipment and, of course, the quality of people's work.

[Question] What do you mean by the quality of concept--is this the improvement of existing methods or creation of basically new ones?

[S.P. Antonov] Before answering your question, I would like to draw your attention to an important fact: the tremendous scale of the present-day metal industry and the gigantic size of its plant units--blast furnaces, open-hearth furnaces, rolling mills, as well as the subsidary facilities serving the main workshops. A modern rolling mill stretches for over a kilometer. A large blast furnace produces 4 million metric tons of cast iron per year. A railroad train carrying that amount of metal would be more than 100 kilometers long. Typically, a city with a population of about half a million grows around a metal works.

This means that even the most revolutionary changes in metallurgy have to occur by means of evolution. Enormous investments and a very long time is required for reconstructing metallurgical processes. And yet, this reconstruction has already begun.

Correspondent's Comment

More than a century ago, after Henry Bessemer invented the converter and Pierre Martin invented the open-hearth furnace named after him, the following process of steel production was developed.

First, a part of dead rock is removed from the extracted ore (the ore is concentrated) and the ore is loaded into a blast furnace. In the furnace, iron is reduced from the oxides in which it is contained within the ore, but then immediately converted to cast iron--an alloy with carbon, which is present in the furnace in large amounts (after all, coke is virtually pure carbon!). The cast iron produced by the furnace is then melted in open-hearth furnace, converters and electric smelters to reduce the excess of carbon and produce steel. Steel is cast into molds and then sent for reworking on rolling mills. The bulk of ferrous metals produced today go through this process.

[Question] What ideas are at the base of the reconstruction that has been started?

[S.P. Antonov] One major trend is the transition from traditional two-stage process of steel production to direct production of steel from the ore. This means eliminating from the production line the blast furnace--this huge complex and expensive plant. With the new procedure, iron-ore concentrate is produced from concentrated ore in the form of large lumps or pellets. The pellets are calcinated in shaft furnaces and then subjected to so-called metallization: They are reduced by converted gas. As a result, the iron content in the pellets is raised up to 95 percent. The pellets are then forwarded to electric furnaces for steel melting.

The electric metal works recently built at Staryy Oskol operates according to this procedure.

At present about 10 percent of steel is produced worldwide with direct iron reduction. At first glance, this does not seem all that much. But development trends are even more important than the results achieved, and here we see that within 10 years the amount of steel produced by the new technology has been increased fivefold!

[Question] What is going to happen to blast furnaces and open-heart furnaces?

[S.P. Antonov] They will still serve mankind. But, certainly, after significant modernization. Today, about one-third of all cast iron and more than half of steel is being produced in the USSR on equipment with long service life (which means that this equipment no longer meets modern requirements). For this reason, five-year-plan schedules call for spending 50 percent of investment in metallurgy on reconstructing and retooling the existing capacities. In 1986 alone, 10 open-hearth furnaces will be shut down and replaced by more progressive converters and electric furnaces!

[Question] You have called the transition to direct production of steel from ore one of the main trends in the development of metallurgy. Does this mean that there are other trends as well?

[S.P. Antonov] The transition to continuous processes is another no less important and effective development.

Metallurgists have long dreamed of creating plants that would produce steel not in separate melting sessions but continuously. This dream is now coming true. First installations of this type are already operational. Their name still doesn't sound familiar: SAND [continuous-action steel-melting plant]. Liquid cast iron passes in this plant through two flow-through baths placed in a sequence and serving as refining apparatus. In the first bath, silicon and manganese and part of carbon is removed from the cast iron. In the second bath the metal is finally converted to steel--with a complete removal of remaining excess carbon and also sulfur and phosphorus.

Building a steel-melting production section operating with this new procedure today costs 30 percent less than building a conventional plant of the same productivity. Obviously, the cost of the metal produced is also lower. In addition, the operation of this new production line can be automated completely.

[Question] If I understood correctly, steel flows as water from a faucet from this continuous-action steel-melting plant.

[S.P. Antonov] Don't forget that the temperature of this flow is over 1500°C.

Correspondent's Comments

Until recently, metal was cast into molds in all steel-melting workshops. A quarter century ago metalworkers and machine builders scored a major success, which was certainly a most important development of the 20th century. They developed and put into operation a method of continuous casting of liquid metal.

Here is how it works. From the ladle the metal is poured not into a mold but into the crystallizer--a bottomless copper mold with cooled walls. Coming into contact with the cold walls, the metal soon becomes covered with a hardened crust; something much like a square tube with jelly inside comes out of the crystallizer. The jelly is the liquid steel and the walls of the tube are the hardened steel crust.

The "jelly tube" is bent smoothly along a circular arc and, descending from a great height, falls on a transporter belt with rollers. By then it is solid and can be cut into pieces without danger of spilling the liquid filling.

Now imagine that instead of ladle used to pour the metal into the crystallizer we have a SAND and the "jelly tube" on the transporter is not cut

into pieces but forwarded before it gets cold (and sometimes even slightly heated up) into the rollers of a rolling mill.

Can you visualize it? This is a picture of the metallurgical section of a factory of the future.

[Question] Sergey Pavlovich, our conversation began with the "quality of an idea." Now, can you specify on what scale the brilliant quality of the idea of continuous metallurgical processes will affect the quantity of metal received by mankind?

[S.P. Antonov] Certaintly. With SAND's it is possible to produce 2-2.5 percent of quality metal more than with the conventional processes. The continuous casting gives us about an equal gain. And the rolling of the "jelly tube" with minus tolerances produces an additional savings of 6 to 7 percent of metal.

[Question] What is rolling with minus tolerances?

[S.P. Antonov] It is virtually impossible to manufacture products with an absolutely exact size. The standards, therefore, allow a certain tolerance range. For example, in the rolling of 10-millimeter sheets, a sheet 9.4 millimeters thick and a sheet 10.4 millimeters thick are both considered acceptable.

A designer and a process engineer must always be oriented by the possibility of a lower limit, in this case 9.4 millimeters. This means that each additional fraction of a millimeter of the thickness above this is not just useless but is damaging. Subsequently, this amount of metal will have to be removed at a cost of energy, time, labor and money. Lately, rolling mills have been furnished with systems controlling the thickness of rolled materials, which made it possible to drastically reduce the scatter of product sizes and bring them close to the minimum admissible limits.

The percentages of savings that I have mentioned may not seem high. Combined they make up 10-12 percent (strictly speaking, this is not the proper way of estimating, but the error is insignificant). But remember that our end goal is to raise the use value of metal by 1.5 times, i.e., by 50 percent. That means that our 10-12 percent is a significant contribution to the common cause.

[Question] What is the main factor limiting the lifetime of a metal product? Destruction by overloads? Obsolesence or physical wear and tear? Or maybe the trivial rust? After all, if you ask a motorist what is his primary concern, the answer would be not the engine, not the brakes, not even the notorious problem camshaft plaguing Zhiguli car owners. The main concern is the body. What can be done to save it? Can the underbody be coated?

[S.P. Antonov] This is of course not just car owners' concern. Carmakers know well that if instead of ordinary metal they take sheets with protective

coatings, the lifetime of the body can be greatly increased. For example, a body of zinc-plated steel serves 4 to 5 times as long. The same is true of roof iron. The effect there is even more striking: The service life is increased by a factor of 8 to 10!

[Question] Do metals have, so to speak, internal reserves... Is it possible to substantially improve other properties of metals, so that a metal made of scarce materials had a much greater strength?

Correspondent's Comments

In the long chain of transformations experienced by material on the way from ore to the finished product, there is a weak link--crystallization: the transition of the metal from liquid to solid state. When molds are used, this process takes a long time. Plus, metal is cooled unevenly: faster near the walls and slower inside (even in continuous casting, crystals first begin to appear at the edges). Because of the slow cooling, metal becomes coarse-grained, with different size of grains at the edge and in the middle of a billet. As a result, metal is nonuniform in its properties. In working with it, one has to be oriented, naturally, by the lower values of its characteristics. Theoretically, the ultimate strength of pure iron is in excess of 1000 kilograms per square millimeter. In other words, wire of pure iron with a cross section of 1 square millimeter should not break even when a weight of 1 metric ton is suspended from it.

But an engineer's handbook would give a totally different number. Instead of a metric ton, it would be just 20 kilograms, because it refers not to an ideal crystal but to a real metal with defects inevitable in manufacturing and processing.

[S.P. Antonov] In a large billet, regrettably, undesirable processes will always occur. In fact, for this reason it has been decided to give up billets and use fine powder instead.

Correspondent's Comments

This is how it is done. First, a metal is melted, that has a composition which, according to metal physics, should provide the characteristics desirable for a designer. If this metal is poured as a thin jet from the furnace and a powerful flow of neutral gas is directed at this jet, the stream of gas will destroy the jet, breaking it into minute drops similar to what is observed at the nozzle of a sprayer.

The diameter of such a droplet can be one-thousandth of a millimeter. Naturally, the drops cool quickly and crystallize in fractions of a second. As a result, we have metal with a perfect small-grained structure and a uniform chemical composition. This is something that metallurgists and machine builders have dreamed about for centuries.

The resulting powder can be poured into a mold shaped as the future product and maintained for a long time at a relatively high temperature of about 1000 °C. As a result, the powder is sintered and becomes monolithic. Here, however, the metal is exposed to the same threats as when it is cooled in molds.

[Question] How can one convert the powder into a product or a finished machine component avoiding this?

[S.P. Antonov] One must drastically reduce the time and temperature of the sintering process. This is achieved by applying very high pressures of hundreds and even thousands of atmospheres to the powder during the sintering process.

[Question] What kind of plant is capable of creating and sustaining such pressures, especially at temperatures of a thousand or more degrees Celsius?

[S.P. Antonov] This brings us right to the difficult problem of juncture between the ideas of metallurgists and the implementation of these ideas by machine builders. This is the juncture between the production process quality and the equipment quality.

Giving the Floor to Machine Builders

[B.V. Rozanov] Present-day metallurgy operates with pressures of thousands of atmospheres. Until recently, however, the pressures rarely exceeded 300 atmospheres in the industry, and even those pressures were considered highly dangerous. And yet under the direction of the recently deceased Aleksandr Ivanovich Tselikov, VNIImetmash [All-Union Scientific Research Institute of Metallurgical Machines] has created essentially new machines (called gasostats) in which it is possible to produce, from powder, articles more than a meter across and up to two meters tall at pressures of up to 2000 atmospheres and a temperature of 1500°C and higher. This is a major accomplishment of designers and probably the most important development in metallurgical engineering in the past few years.

[Question] What are the advantages of products made from powders?

[B.V. Rozanov] I will give just two or three examples. Metal rolls made of powders have a service life 50 times as long as that of conventional rolls. Cutters, drills, taps, reamers and other cutting tools made of the same steel but by powder metallurgy can be used to process 2-3 and sometimes 6 times as many blanks as the conventional tools.

And the final example--disks and blades of heat-tolerant nickel alloys for aircraft turbines. When made of powder and processed in gasostats, the working temperature in the engine can be raised by several tens of degrees. That produces a tremendous gain in the engine efficiency.

Viktor Ivanovich Trefilov, vice president of the Academy of Sciences of the Ukrainian SSR, has estimated that for every 1000 metric tons of products made

of powder the nation saves about 2000 metric tons of metal and the labor of 192 workers; that amounts to reducing the number of metal-cutting machine tools by 80 and obtaining a savings of 1.5-2 million rubles.

This is a perfect example of a high-quality idea, in this case an idea that revolutionizes both production processes and engineering.

[Question] But I am sure the designers had to confront a lot of difficulties?

[B.V. Rozanov] When the institute was first faced with the objective of creating machines with a very high pressure, one of the most complex problems was to secure the strength of the container--the unit in which the pressure would be created.

The container is a thick-walled cylinder. As long as we were dealing with hundreds and even a thousand atmospheres, no special problems arose. The higher was the desired working pressure, the thicker would be the walls of the cylinder.

But when a container capable of withstanding pressures of 5000 atmospheres was required, the conventional solution was no longer acceptable. The implacable laws of the elasticity theory produce a much higher pressure on the internal layers of a container wall than on the external layers. So the thicker a container wall, the less useful work is done by the external layers. The engineers found themselves in a vicious circle. For raising the working pressure, they had to make the container wall thicker. But as they made it thicker, the properties of the metal deteriorated. Once the properties deteriorated, the admissible working pressure went down. The way out of this impasse was a new design concept. The engineers took a thin-walled bushing which, as such, would be incapable of withstanding even several hundred atmospheres, not to mention a thousand. But this bushing was wrapped as a spool with many layers of a thin ribbon. The result was a very strong structure. The reason is that the properties of a thin ribbon are better as a factor of 1.5 and sometimes 2 than the characteristics of the best grades of a steel of a larger cross section. Steel used to make large containers rarely has an ultimate strength better than 120 kilograms per square millimeter. The strength of a wire, on the other hand, is 180-190. If they make a special effort, the rolling mill engineers can produce steel ribbons up to 250 and even 300 kilograms per square millimeter strong. The high strength of the thin ribbon is combined with a sufficient plasticity; the number of turns in a container reaches tens of thousands. That means that an accidental breakage of a turn or even a dozen turns will pass unnoticed by the structure.

Remarkable experiments have been conducted by our institute: The winding in container models was damaged and the behavior of the containers observed. Even when 30 percent of turns were damaged (!) the admissible pressure for the container still was not reduced. Another important merit of the new structure is that the numerous turns cannot all fail at the same time. This practically rules out an accident --- an explosion of the container.

[Question] Boris Vasilyevich, if containers of gasostats are highly reliable and quite safe, can't this be said about the gasostat structure as a whole?

[B.V. Rozanov] Certainly. The container is just one of the components of the machine. Even though it is the most important and crucial component, it is just one out of many. The problems of safety and reliability had to be solved for all the components! In this context, I would like to mention just one more element of this structure--the support bed.

In a large gasostat the support bed should sustain a tremendous force--tens of thousands of metric tons. By its function it is in many ways similar to the beds of high-power presses. But while the breakdown of this part of a press would not cause disaster, in a gasostat that could have catastrophic consequences.

VNIImetmash also uses high-strength ribbon to reinforce the support beds of gasostats; as a result, they are perfectly reliable and, in addition, by two and even three times lighter than the conventional beds. For this reason, beds with winding in recent years have been used commonly not only in gasostats but in presses as well. They will certainly find applications in many other types of machines, producing a tremendous savings of metal. This is another example of the effectiveness of a quality idea.

[Question] Are the gasostats themselves used only to produce articles from powders or for some other purposes as well?

[B.V. Rozanov] You have probably heard of the phenomenon of metal fatigue. When loads experienced by a component vary during the course of operation, gradually (sometimes after thousands of hours), there develop microscopic defects which may be accumulated and result in a breakdown. Tests have shown that if a component that has worked out all of its service life is placed in a gasostat and exposed to a uniform gas pressure, foci of fatigue damage disappear completely. The component becomes as good as new.

[Question] Can this component be installed back into a machine?

[B.V. Rozanov] Absolutely. After gasostatic treatment, the components have the same service life reserve as they had originally. Furthermore, after the component works out its service time it can be placed again into the gasostat and "rejuvenated." This technology, created in recent years, has been estimated to promise savings measured no longer in millions but in billions.

[Question] Boris Vasilyevich, what you have just said about gasostatic treatment of machine components is a graphic illustration of unexpected and profitable effects that may arise at the juncture of technologies.

[B.V. Rozanov] Speaking of metallurgy and engineering industry, the "juncture effect" has been known here since a long time. Rolling has been viewed

traditionally as a metallurgical process. Until the middle of this century, rolling mills operated only at metal works.

Yet back in the last century it became clear that the tremendous advantages of rolling--and especially the high productivity in producing a desired shape--could be used not only to manufacture sheets, strips, pipes and shapes. Back then, special rolling mills were created to make the tires of railroad wheels and then the wheels themselves. Yet again, this was done at metal works.

Aleksandr Ivanovich Tselikov advanced a daring and progressive idea--using rolling procedures to make exact blanks of machine components directly at engineering factories. Starting in 1945, VNIImetmash launched projects to create the industrial processes and special rolling mills for this purpose.

Today such mills operate at many factories across the country, making balls, rolls, bushings, axles, gears and sprockets and other components used on a large scale. This does not happen only in the Soviet Union. VNIImetmash has sold original component-rolling mills to Britain, Japan, FRG, Sweden and Bulgaria.

[Question] The components that you mentioned--balls, rolls and even gears--are relatively simple in shape. Is it possible to roll more complex articles?

[B.V. Rozanov] Not only possible, but it is happening. If you come to Leningrad, you could make a tour of the Arsenal Factory. There you will see rolling mills producing rotors for impeller compressors. This is an involved worm-shaped component. Large-lead screws, such as the lead screws of machine tools, are also shaped between rolls. The rolling has a very high speed--up to a meter per minute. This is 10 to 20 times faster than machining on a lathe or thread-mills. It also saves 10 to 15 percent of metal, and the quality of the screws is much better: the static strength is increased by a factor of 1.2 and the fatigue strength more than doubled.

[Question] Is it possible to make component blanks with a central hole on a rolling mill? This is also a very common type of component.

[B.V. Rozanov] Certainly. A good illustration is the production of the hubs for the back wheels of bicycles and races for ball bearings. Remarkably, they are made from a simple rod. The first operation is making a hole in it. It is not drilled, but pierced in hot metal--the rolling occurs virtually with no waste. The resulting rod with a center hole is formed into the desired shape between rolls without any additional heating. The efficiency of the process and the machine can be gauged by these numbers: the First State Ball Bearing Plant produces 20 million (!) blanks of races for conical bearings every year for the nation. The savings amount to almost 30 percent of expensive doped steel.

According to the plans laid down by the 27th Congress of the CPSU, the output of rolled products by 1990 should be raised to 116-119 million metric tons.

This is not a significant growth. In addition, as was specially noted in the resolutions of the congress, the growth should be achieved without increasing the output of cast iron and while reducing substantially the consumption of coke!

This is a drastic turnaround in our technological policy. It is a turn from extensive development methods--by increasing the production outputs--to intensive methods. This is the goal that VNIImetmash engineers seek to achieve in developing the essentially new machines--the machines which raise labor productivity and product quality rather than increasing the quantity of metal processed.

A drastic retooling of metal works will also promote this goal.

We have discussed many of the links in the chain leading from crude ore to the finished machine. Each link represents the work of hundreds of thousands of people. This means that the fourth factor--the quality of work--is extremely important. Each of us should bear that in mind.

9922
CSO: 1842/267

MEETING ON INCREASING USE OF OSKOLSKIY ELECTROMETALLURGICAL COMBINE METAL

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 19 Aug 86 p 2

[Article by O. Buzuluk, special correspondent, under the rubric "Returning to What's Been Printed:" "In Different Languages;" text in slantlines printed in italics]

[Text] /The hall of the collegium of the Ministry of Ferrous Metallurgy looked different. Huge rings and heavy rounds of metal were placed neatly on the table, and tables and diagrams dotted with figures hung from the walls. In addition to the hosts, those who develop and certify GOSTS, standards and prices for metal products and are responsible for their rational use in the national economy are gathered in the hall./

The reason for the meeting of the collegium was a letter by B. Kirgizov, a steelworker at the Oskolskiy Electrometallurgical Combine, printed in August 5's SOTSIALISTICHESKAYA INDUSTRIYA under the heading "Lost Advantage," and the commentaries on it by staff correspondent Yu. Antropov. Let us refresh your memory: the subject was the slow assimilation of the design assortment at the enterprise and problems in selling high-quality metal produced with an essentially new, progressive technology.

Minister Serafim Vasilevich Kolpakov immediately set the tone.

"So why must the newspaper suggest how to solve our problems -- that's the task of the industry staff. Eight months have passed since the first melt, and we are still scrutinizing, evaluating...We've lost the reins of government at "Soyuzspetsstal," and the sector's science hasn't turned out to be the tops. Did we really not know about the imminent difficulties? Of course we knew: we've been tossing them around for 20 years. Exactly two years ago we gathered representatives from machine-building ministries, the all-union Gosplan and Gossnab, and other departments. We warned that we were soon starting up the combine. We asked them to take into account that it would produce high-quality metal which would be more expensive than ordinary. Estimate, they said, what it will go for..."

The minister was correct: metallurgists tried to outsmart events. But apparently they were inadequate, not energetic enough. They couldn't take into account the sad lessons of the not so distant past.

The Nizhniy Tagil Metallurgical Combine, where they mass produce wide-flange beams for capital construction, bore multimillion-ruble losses at its time. They produced and produced, but the order file was more than half empty: builders hesitated to switch to the new product. A similar situation occurred with output of high-precision shapes at the Omutninsk Metallurgical Plant in Kirov Oblast. Users had long been accustomed to the fact that they would be supplied with articles which did not need machining. But miscalculations with vacuumized steel? Now this same story is being repeated at Staryy Oskol.

"At the end of July we had smelted a million tons of steel," the Combine's chief engineer, V. Simurzin, reported to the collegium. "And 1.4 million tons was already planned for next year. Today our metal can replace some of what the country imports. But no one will take it."

S. Kolpakov: "You developed a grade -- guarantee its delivery and demand distribution. You yourselves had to make sure that the metal goes strictly according to purpose. With whom did you work, just who turned you down?"

V. Simurzin: "It's difficult to say specifically..."

V. Vanchikov, deputy chairman of USSR Gosplan: "How is assimilation of the disign assortment going?"

V. Simurzin: "We confidently smelt up to 80 grades, about one-fifth the assigned assortment. There is still a lot of waste because of violations of casting technology and other miscalculations. We are now working on eradicating them. We will be starting up a rolling mill at the end of the year. We are eliminating many problems."

The head of USSR Gossnab's Administration for the Supply and Rational Use of Ferrous Metals, M. Starovoytov, joined in the conversation: "We can discuss selling only guaranteed lots of metal. Our specialists are now busy preparing workload protocols for next year. Are you ready to ensure stability of deliveries?"

V. Simurzin: "In principle, we are. But there is still much to be done..."

In the opinion of the director of the sector's lead institute, TsNIIchermet [Central Scientific Research Institute for Ferrous Metallurgy], the basic directions in using the product of the Oskolskiy Combine in the national economy have already been clearly defined. Now, if all the metal is to be used, we must accustom buyers to price mark-ups for quality. Are the appropriate departments ready to decide this problem?

The discussion at the collegium showed that, unfortunately, they are not. B. Fedin, head of Gosstandart's [State Committee for Standards] Metallurgical Industry Administration referred to lack of direct instructions from his management. Deputy Chairman of USSR Goskomtsen [State Committee on Prices] L. Rozenova, while recognizing a need for a more flexible approach to prices, said that the Committee itself can decide nothing without the machine-building ministries.

In a word, both departments still take a wait-and-see position. Meanwhile, it is clear that supplying metal with exceptional properties at the price of ordinary metal means breaking the machine-builders' thinking habits and trying to find assemblies where Oskolskiy metal can have greatest national economic impact. But, apparently, departmental interests still come first.

"We will use only what is good for our enterprise," opines Deputy Head of the Technical Administration of Mintyazhmash [Ministry for Heavy and Transport Machine-Building]. "Our long-range plans do not include Oskolskiy metal."

Nor did the presentation of the head of Minstankoprom's [Ministry of the Machine Tool and Tool Building Industry] Main Industrial Administration, V. Nesterenko, particularly raise hopes: "We are interested in obtaining steel grades assimilated by the combine. But only if we do not incur losses from a price increase..."

A decree adopted at the collegium meeting affirmed a program of measures to completely assimilate the Oskolskiy Electrometallurgical Combine's design assortment. Responsibility for monitoring its implementation was assigned to First Deputy Minister of USSR Ferrous Metallurgy L. Radyukevich. It is to be carried out from August to December of this year.

Those who ineffectively solved the problems posed by the newspaper on studying the characteristics of the Oskolskiy output and strengthening relations with its users have been punished. Director of TsNIIchermet's Institute for New Metallurgical Technology V. Sinelnikov, Director of the VNITI [All-Union Scientific-Research and Design-Technologic Institute for the Pipe Industry] O. Semenov, and Director of "UkrNIIspetsstal" [Ukraine Scientific Research Institute for Specialty Steel] G. Kaplanov were reprimanded. A. Ugarov, director of the Oskolskiy Combine, received a warning.

However, the metallurgists have not found a common language with the sub-contractors and the central planning and pricing authorities in the general interests of the State. This must be done without delay.

12809/12955
CSO: 1842/263

NEW CHEREPOVETS BLAST FURNACE PRODUCES FIRST MILLION TONS

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 20 Aug 86 p 1

[Article by V. Minin, Cherepovets, under the rubric "Reportage": "The First Million from 'Severnyaka'"; text in slantlines printed in italics]

[Text] /You have to gaze in admiration when, along the wide driveway, the "Severnyaka" blast furnace operators file into the casting yard. Stepping broad and free, they look like real bogatyrs in their woolen overalls and broad-brimmed felt caps. Especially now, when the country has received the first million tons of pig iron from the fifth Cherepovets blast furnace./

Any of the blast furnace operators here is worthy of high praise -- both furnace foremen B. Kurlikov, N. Ziganshin and G. Vasinev and first blast furnace attendants P. Berdnikov, V. Kotov, P. Malyshev and their comrades in this hot work. It is they who have performed a real feat of labor, bringing the country's largest blast furnace to design capacity a half year ahead of schedule.

...It seems like only yesterday: a bright sunny day, last April 14, a meeting of thousands in the area next to the blast furnace in honor of the first iron produced. First Blast Furnace Attendant Sergey Nadeyev on the red-cotton-covered rostrum with the symbolic key to "Severnyaka" held high above his head.

"We won't spare ourselves to bring our 'Severnyaka' to design output early," he assured all the metallurgists in the name of the blast furnace operators.

And they kept their word. The standards allocate 10 months to bring an iron-melting ocmplex of this size to design level. The Cherepovets blast furnace operators did it three times faster: on July 18, 10,000 tons of iron per day were already being melted.

Some thought that the furnace would operate for another day or two at design productivity and then the pace would slacken. Such things have happened. The blast furnace operators themselves feared this. They were so anxious that V. Novikov, acting head of the blast furnace shop, appeared at a directors' reception in honor of Metallurgy Day, straight from the casting yard in his workclothes, all dusty with graphite.

There was reason for anxiety. So much molten metal per day from one casting yard has to be a joke. But one week passed, and another, and "Severnyaka" efficiently produced its daily 10,000 tons of iron. The design limit became the norm. Meanwhile, alongside, four "old" Cherepovets furnaces, also operating at maximum capacity, were melting another 17,000 tons of metal. The iron was then sent to the open hearth, the converter and for casting. Adapting to "Severnyaka's" rhythm, the casting section, with a cold iron storehouse, had to quickly expand to an annual capacity to ship two million tons of metal.

"We rebuilt that too, along the way," says V. Novikov. "We monitored 'Severnyaka's' impetuous course, but it dictated its own conditions and kept us in constant readiness. At first, the casting yard machinery often broke down, especially the iron notch guns for closing iron tapholes and boring machines. And there were accidents."

Overcoming the furnace's whims, the people studied and mastered the equipment. Of course, even today certain electric circuits, items under suction, screens at the bin trestle, for example, have to be modified, and granulators, automation systems, and some of the power equipment have to be improved. Now all this has to be put right by the efforts of the combine's blast furnace operators and repair services.

Both the plant's directors and workers are equally concerned about the situation at the fifth blast furnace.

"How's the fifth?" is the first question Director Yu. Lipukhin asks the chief furnace operator every day at the morning briefing.

I've just returned from the Kostomuksha miners with the totals for our interindustry socialist competition," says USSR Supreme Soviet Deputy and First Furnace Operator P. Berdikov. "They firmly promised that they won't send pellets. There will be raw iron ore -- and pig iron.

The experienced blast furnace attendant is restrained in evaluating the first million tons of iron from "Severnyaka." He knows all the furnace's strong and weak points. He can compare -- he has worked on the four Cherepovets blast furnaces.

"The first million tons is a test of our strength -- and a demand to accelerate -- to new millions. This unit should produce much more iron, expecially since there are reserves. For example, we still don't make complete use of oxygen. Winter is coming, and with it our concerns about supplying the furnace, about the operating reliability of all "Severnyaka's" numerous systems in cold weather..."

...One after another, in a circle, at brief intervals, the furnace operators open the giant furnace's iron tapholes to make way for the finished metal. The rhythm of smooth iron production has been 100 percent developed -- according to all the rules of the Cherepovets Furnace Operators' School. And it is considered one of the best in the country.

12809
1842/263

BRIEFS

NOVOLIPETSK COMBINE PRODUCT SHIPPED--Lipetsk--August marked an important event for the youngest collective at the dynamo steel shop of the Novolipetsk Metallurgical Combine imeni Yu. V. Andropov: shipment of finished product to users began. The first lot -- more than 2,000 tons of high-quality dynamo steel -- was shipped on order to the Kemerovo Electric Motor Plant. [by N. Klimov] [Text] [Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 20 Aug 86 p 1] 12809/12955

CSO: 1842/263

UDC 669.18.046.518-412:621.746.62

CHANGE IN DEGREE OF OXIDATION OF RIMMED LOW-CARBON STEEL DURING SOLIDIFICATION OF LARGE SHEETS INGOTS

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 6, Jun 86 (manuscript received 14 Mar 85) pp 38-40

[Article by R. P. Konovalov and V. V. Senichkin, Ferrous Metallurgy Institute, Dnepropetrovsk]

[Abstract] A study was made of the oxidation kinetics in rimmed low-carbon steel during pouring of the melt with the addition of aluminum as deoxidizer and borax as synthetic slag former, and during subsequent solidification in the ladle. Molten 08kp steel was poured down from a double-chamber furnace holding 14 t for sheet ingots, at a velocity of 1.0-1.5 m/min. The liquid core in the ladle was sampled 300-400 mm below the free surface during solidification at intervals of 4-7 min over a total period of 24-30 min. Specimens cast into cylinders 150 mm long and 21 mm in diameter, weighing approximately 350 g, were analyzed in an AN-160 apparatus for carbon content within $\pm$.0 and in a "Baltzer" EAO-202 exhalograph for overall oxygen content. During the initial period in the ladle hardly any change occurred in the 0.061% average carbon content, but the oxygen content decreased appreciably to an 0.0394% average as compared with the 0.0484% average in unrimmed reference specimens. This change is attributable to the presence of a slag forming mixture as well as to a smaller amount of nonmetallic oxides among impurities. During the later period the carbon content also decreased, while the oxygen content first decreased to its average minimum of 0.0354% after 10-17 min and then again increased to its maximum but never as high as original level after 27-30 min. These results can be used for optimization of the rimming time and economizing on the deoxidizer. References 4: all Russian.

2415/12955
CSO: 1842/255

UDC 669.018.25:620.18

NEW WEAR-RESISTANT Fe-Mn-V-C ECONOMY ALLOY STEELS WITH REGULATION OF STRUCTURE

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 6, Jun 86 (manuscript received 28 Jun 84) pp 108-112

[Article by L. S. Malinov, Ye. Ya. Kharlanova, G. A. Chikalenko, A. B. Gogol and L. L. Mudrik, Zhdanov Metallurgical Institute]

[Abstract] New manganese steels for castings have been developed with more initial hardness and better machinability than the 110Mn13 cast Hadfield steel. They contain 0.7-1.3% C, 5.4-10.2% Mn, 0.5-2.7% V and 0.2-1.0% Si as principal alloying elements as well as 0.01-0.06% N_2, 0.01-0.06% Ca, 0.02% S and 0.02% P. These steels were smelted in an induction furnace. Ingots were homogenized at 1100-1150°C for 10 h and then forged into blanks which were annealed at 600-630°C for 30 h before being cut into test specimens. These were quenched from various temperatures covering the 800-1150°C range and tempered at various temperatures from 200°C to 700°C, for subsequent metallographical examination, x-ray phase analysis in a URS50IM apparatus, hardness and toughness measurements and magnetic measurements in a magnetic field of approximately 560 kA/m intensity. A 3-level factorial experiment had been planned, with 1.0/0.994% C - 8.0/8.225% Mn - 1.0/0.968% V - 0.5/0.-546% Si base level, 0.7/0.692% C - 6.0/6.200% Mn - 0.5/0.602% V - 0.0/0.087% Si lower level and 1.3/1.308% C - 10.0/10.250% Mn - 1.5/1.334% V - 1.0/1.005% Si upper level. The most economical grades 7Mn6V and 7Mn6V2 with only 6% Mn were found to have a predominantly martensitic structure with not more than 15% residual austenite after quenching from 800°C, up to 40% residual austenite after quenching from 1150°C, low-temperature tempering then being most favorable for stabilization of residual austenite and relief of internal stresses. The high-manganese steels were found to contain also the ε-phase along with carbides and residual austenite after tempering at 500-650°C. Quenching from 900-1000°C, however, resulted in the maximum toughness of all steels after subsequent tempering. The steels were also tested for wear, block-and-roller pairs of 13Mn8V1, 13Mn6V2, 7Mn6V2 steels under an 80 kg load in the laboratory and hole punches made of 1Mn6V2 steel in an industrial stamping plant. The wear resistance of all these steels was found to be higher than that of the Hadfield steel and other alloy steels. The results indicate that the $\gamma \rightarrow \alpha$ phase transformation and the volume ratio of the two structural components can be widely regulated by varying the heat treatment as well as the C-Mn-V-Si content so as to ensure the mechanical properties necessary for a given application. References 4: all Russian.

2415/12955
CSO: 1842/255

UDC 669.15-194:546.621:620.186.5

EFFECT OF ALUMINUM ON PRONENESS OF LOW-CARBON STEEL TO AUSTENITE GRAIN GROWTH DURING HEATING

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 7, Jul 86 (manuscript received 5 Jun 85) pp 97-101

[Article by Ye. L. Zats, Ye. V. Tinkova, T. V. Rovenskaya, L. N. Kologrivova and A. Ya. Nakonechnyy, Donetsk Polytechnic Institute and Tulachermet Scientific Production Association]

[Abstract] A study of St3sp killed low-carbon steel with varying Al content was made, for the purpose of determining the dependence of austenite grain growth during heating on the Al content. Specimens of 10 mm thick strips were produced from 14 ladles containing 0-0.053% Al soluble in acids. Proneness to grain growth was determined from measurements of the apparent grain diameter by the method of secants, after polished specimens had been annealed in a vacuum furnace at 930,1000,1050,1100,1150,1200°C for 1 h at each temperature under a residual pressure of 1.46 mPa and subsequently vacuum etched for these measurements. The results indicate that aluminum does influence the initial stage of high-temperature recrystallization, namely coalescence of grains, by raising the temperature at which this process begins. They confirm that grain growth is inhibited by aluminum nitride, which forms barriers. Accordingly, at high Al concentrations above 0.010% Al ($Al/N_2>2$) fast grain growth was found to occur at temperatures up to 100°C higher than otherwise. At low Al concentrations up to 0.010% Al ($Al/N_2 \leq 2$) grain growth was found to be limited more by strongly surface active elements and especially sulfur, proneness of this steel to high-temperature recrystallization thus increasing with a decrease of the S content. References 5: all Russian.

2415/12955
CSO: 1842/254

UDC 669.187.25

VACUUM TREATMENT OF HIGH-CHROME MELTS IN THE PRODUCTION OF CORROSION RESISTANT STEEL

Moscow STAL in Russian No 8, Aug 86, pp 35-37

[Article by A. F. Kablukovskiy, P. G. Samoylov, E. F. Mazurov, V. V. Shakhnovich and A. M. Yevgrashin, Central Scientific Research Institute of Ferrous Metallurgy and the Krasny Oktyabr Plant]

[Abstract] A ladle-type vacuum unit equipped with a protective refractory-lined screen and a device for blasting metal in a vacuum with oxygen fed through a water-cooled tuyere was developed. In the development of this technology, special attention was given to 03X18H11 and 03-04X19H9 very

low carbon steels as well as 08X17T and 0812X18H10T steels and others. The oxidation period in the furnace was begun with the chrome content at the upper limit and the nickel content at the medium limit of the grade composition, and the carbon content up to 1.3%, so that high-and medium-carbon ferrochromium and the byproducts of smelted steel could be used in the mixture. The blasting began when the burden was completely melted, and ended when the temperature of the metal was 1760 - 1820°C, and the carbon content was 0.3 - 0.5%. The melt was poured at a temperature of 1700 - 1670°C into a brick-lined teeming ladle equipped with a slide gate. Agitation of the melt with argon fed through periclase tuyeres began at the same time that the steam - ejector pump was turned on. This technique made it possible to reduce the carbon content of the metal to 0.02%, with little (about 0.5 abs.) chrome melting loss. Three different techniques for introducing titanium into the metal were checked to determine the melting loss of titanium during alloying. The titanium assimilation varied from 24 to 65% depending on the alloying method, and was highest when the titanium was introduced as the metal was transferred through a nozzle from the refining ladle to the teeming ladle with the oxidized slag cut off.

13050/12955
CSO: 1842/269

UDC 669.187.012.7

ECONOMIZING ON TUNGSTEN IN THE PRODUCTION OF HIGH-SPEED STEEL

Moscow STAL in Russian No 8, Aug 86, pp 37-38

[Article by V. F. Merkulov, K. K. Zhdanovich and A. A. Kuzmin, Izhstal Production Association]

[Abstract] Research was done to determine the relationship of the time of solution for ferrotungsten during melt agitation with gas bubbles to its diffusion constant, mass and density of the tungsten and metal, amount of oxidized carbon, temperature, height of the column of molten metal, viscosity/density ratio of the melt, and tungsten concentrations in the surface layer and throughout the metal when making high-speed steels. The time of solution in a 25-ton solution with a carbon content corrsponding to that of high-speed steel was determined in relation to the oxidation speed and the amount of oxidized carbon. According to existing technology, during smelting the bath was agitated for 10 - 15 minutes by the kinetic energy of a stream of oxygen and the carbon monoxide formed during blasting. A smelting technique was used at the Izhatal Production Association in which the molten metal was not blasted with oxygen and scales of high-speed steel and coke in a 6:1 ratio and ferroalloys were added to the charge fed into the furnace bottom. Limestone was added to the charge to make the basicity of the slag close to 1. This technique made it possible to reduce the oxidizing potential of the atmosphere by a factor of 1.7 - 2.7. The addition of the scale and coke increased the boiling time of the bath to 15 - 30 minutes. The bubbles that formed around the ferroalloy pieces on the furnace

bottom broke free and agitated the entire solution, thus making the ferrotungsten at a faster rate. This technique allowed increased assimilation of chrome, molibdenum, vanadium and tungsten. References 5: 4 Russian, 1 Western.

13050/12955
CSO: 1842/269

UDC 621.74:669.131.7

MODIFICATION OF LARGE MACHINE BUILDING CASTINGS IN THE MOLD

Moscow LITEYNOYE PROIZVODSTVO in Russian No 9, Sep 86, pp 6-7

[Article by Candidate of Technical Sciences S. N. Lekakh, Doctor of Technical Sciences D. N. Khudokormov, Engineers I. V. Khoroshko and N. I. Bestuzhev]

[Abstract] The branch laboratory of Belorussian Polytechnical Institute has studied factors determining the quality of cast iron with spherodial graphite modified in the mold. The results of the study have allowed an industrial technology to be developed for the manufacture of castings with masses of 0.5-6 t. special studies of the stability of the properties of cast iron with spherodial graphite modified in the mold have shown that at a sulfur content of 0.03-0.05% in the initial melt, the spread of values of impact strength increases greatly. To eliminate this problem, melts can be pretreated with an additive containing rare earth metals, significantly stabilizing the structure and properties of the iron. The temperature of treatment of the iron in the ladle is important, and must be 1450-1480°C. Uniform dissolution of a master alloy containing Mg within a short period of time is also important. The technology is now in use at the Cheboksary Tractor Plant and reduces the consumption of the master alloy by a factor of 2 in comparison to treatment in the ladle. References 1: Russian.

6508/12955
CSO: 1842/6

UDC 621.74:669.13

PRODUCTION, PROPERTIES AND AREA OF APPLICATION OF CAST IRON WITH VERMICULAR GRAPHITE

Moscow LITEYNOYE PROIZVODSTVO in Russian No 9, Sep 86, pp 7-9

[Article by Professor Ye. Nechtelberger, Austria]

[Abstract] A process for production of cast iron with vermicular graphite was patented in Austria in 1968. A method of magnesium modification with simultaneous introduction of despheroidizing elements was patented in 1965-1966 in the U.S.A. and England, and has been used since 1976 in the U.S.A.

under the name CG Technology. A method based on introduction of magnesium or magnesium master alloy in a quantity insufficient to produce spherodial graphite has also been developed, as well as a method for production of vermicular graphite cast iron by modification of ordinary cupola cast iron with high sulfur content using a master alloy containing, Mg, Ce and small quantities of Al and Ca. Comparative economic analysis has shown that under otherwise equivalent conditions, vermicular graphite cast iron can be produced some 45% cheaper by the method using cerium than by treatment of cast iron with a magnesium master alloy containing titanium as in the CG process. Vermicular graphite cast iron can be used in the manufacture of various motor vehicle parts such as exhaust manifolds, as well as railroad disc brakes and turbine bodies.

6508/12955
CSO: 1842/6

UDC 621.74.046

DIFFUSION REDISTRIBUTION OF ALLOYING ELEMENTS IN THE FORMATION OF BIMETALLIC CASTINGS

Moscow LITEYNOYE PROIZVODSTVO in Russian No 9, Sep 86, pp 9-10

[Article by Candidate of Technical Sciences, G. D. Kostenko and Candidates of Physical-Mathematical Sciences V. B. Brik, V. V. Gorskiy and Ye. K. Ivanova]

[Abstract] A study was made of the redistribution of alloying elements in the zone of diffusion interaction of liquid and solid metal for a number of bimetallic pairs. The area of diffusion redistribution of atoms of the metallic elements in the carbide-free area amounts to some tens of micrometers. Metal atoms penetrate into the matrix of the steel only to a depth of a few micrometers. The somewhat elevated content of some alloying elements in steel is probably a result not of diffusion through the volume but directed and accelerated migration of atoms along casting defects, crystal boundary surfaces, microscopic cracks and other defects. The role of processes of redistribution of metal elements and carbon occurring during the production of bimetallic castings differs significantly. Whereas the redistribution of alloying elements into the matrix of the metal is responsible for the strength of the bond, the process of redistribution of carbon, forming a carbide-free layer, largely determines the good ductility observed in steel-cast iron bimetallic specimens. References 1: Russian.

6508/12955
CSO: 1842/6

UDC 621.74.043.002.6

ADAPTABILITY TO MANUFACTURE OF CASTINGS PRODUCED USING GASIFIED MODELS

Moscow LITEYNOYE PROIZVODSTVO in Russian No 9, Sep 86, pp 14-15

[Article by Candidate of Technical Sciences V. A. Pavlov]

[Abstract] Production of castings using gasified polystyrene foam models changes the concept of the adaptability to manufacture of a casting design, since the model need not be extracted from the mold after the mold material has been cured. This expands the adaptability to manufacture of the process, allowing an increase in the quality of castings and permitting designers to plan cast parts with configurations most fully corresponding to the working conditions of the castings. This article discusses requirements for the use of these models, including proper selection of wall thickness considering the mechanical properties of the model material and selection of the casting mold material to have good gas permeability and the ability to flow around the model without requiring destructive pressure to set. Requirements for mold shapes and production processes are outlined, considering the pressure sensitivity and fragility of the polystyrene models. The author suggests development of technical standard documentation on the production of castings from gasified models. References 6: all Russian.

6508/12955
CSO: 1842/6

UDC 621.74.045

MATERIAL-CONSERVING TECHNOLOGY FOR CASTING PRESSING TOOLS

Moscow LITEYNOYE PROIZVODSTVO in Russian No 9, Sep 86, pp 15-17

[Article by Candidate of Technical Sciences L. A. Shcheglovitov, Engineers A. R. Kozin and V. I. Ulshin]

[Abstract] A technology has been developed for manufacture of press blades by investment casting using melted or gasified models in ceramic block molds. Drawings of molds used are presented, plus a description of the casting process and equations to be used to design elements of the riser system. Models are removed from molds by melting with hot air or gasifying in a furnace before pouring, after the riser is removed. Anode-mechanical or electric errosion methods are used to remove the riser from the casting. The economic effectiveness of the new technology results from increasing the material usage factor from 0.4 to 0.85, decreasing the mean cost of the parts from 14.36 to 6.53 rubles per kg and increasing the operating life of the parts by 30 to 100%.

6508/12955
CSO: 1842/6

UDC 621.746.558:669.715

FILLING OF MOLDS IN PUNCH AND PUNCH-PISTON PRESSING OF SILUMINS

Moscow LITEYNOYE PROIZVODSTVO in Russian No 9, Sep 86, pp 19-20

[Article by Candidates of Technical Sciences V. I. Bezpalko and A. I. Batyshev]

[Abstract] A study was made of the filling of molds during punch and punch-piston pressing of castings of alloy AL2 with crystallization under pressure. The length of piston channels 1.5 mm in diameter was used to determine the filling of the molds during casting of cup-shaped and stepped cylindrical-shaped castings. The castings were produced at a nominal pressure of 100 MPa at 100 K above the liquidus, initial mold temperature 390 K, holding time in matrix before application of pressure 4 seconds. The results of the studies were used to develop a technology for production of thinwall castings at the Bobruysk Balance Plant. The mass of castings was decreased by 15 to 20% by decreasing wall thickness. References 2: both Russian.

6508/12955
CSO: 1842/6

UDC 669.715.48:621.74

IMPROVEMENT OF MELTING OF ALUMINUM ALLOY WASTE AND SCRAP IN ELECTRIC FURNACES

Moscow, TSVETNYYE METALLY in Russian No 8, Aug 86 pp 74-77

[Article by A. G. Mazhan, B. I. Yemlin, V. A. Popov, S. N. Kilesso and V. N. Yakonova]

[Abstract] It is difficult to produce high quality alloys from aluminum scrap and waste since the charge contains elements which influence some of the parameters of the physical and chemical interaction of the liquid metal with the surrounding atmosphere. The use of powder flux results in the formation of a dry slag which adheres to the crucible walls, reducing power transmission through the walls and causing hot spots. The use of a flux bath is based on liberation of heat as electric current passes through the melted flux. Studies were performed by this method with an altered crucible design in a commercial furnace. Effective heat utilization is determined by heat transfer from the flux to the metal. The melting rate therefore depends on power applied and flux temperature, heat transfer from flux to metal, flux bath thermal inertia, and location of heat liberation zones. It was found that almost two-thirds of the energy was liberated near the electrode in the experimental bath, leading to maximum heating of the flux near the electrode. This resulted in very low flux inertia. The use of a liquid flux bath with independent power supply was found to increase extraction by 1.5-2%, decreasing metal content in the slag by up to 3%. The solid charge was constantly in a volume of melted flux and metal droplets formed were fully isolated from the atmosphere, eliminating oxidation. References 10: all Russian.

6508/12955
CSO: 1842/270

UDC 546.2:621.315.592

NEUTRON DOPING OF SILICON PRODUCED BY THE CHOKHRALSKY METHOD

TSVETNYYE METALLY in Russian No 8, Aug 86, pp 58-61

[Article by Yu. M. Babitskiy, I. N. Voronov, P. M. Grinshteyn and Kh. I. Makeyev]

[Abstract] Previous studies have shown that the process of annealing of radiation defects depends essentially on bombardment conditions and the impurity composition of the material. Neutron bombardment greatly accelerates the decomposition of a supersaturated solid solution of oxygen in silicon and the generation of high temperature donors. According to the classical theory of seed formation the incubation period of this process is related to the formation of critical seeds. In the case of preliminary annealing these seeds are complexes of several oxygen atoms formed homogeneously by diffusion. In the case of bombardment they may be either radiation defects or homogeneous oxygen atom centers formed due to radiation-acceleration diffusion of oxygen atoms. In order to determine the mechanism of acceleration of precipitation, the kinetics of the process were studied at 750°C after bombardment with neutrons at various temperatures. The appearance of electrical activity of oxygen complexes was studied in silicon crystals bombarded with neutrons during heat treatment. The temperature variation of the fraction of carbon atoms which do not move to the lattice nodes during annealing showed that it can be described by an exponent with an activation energy of about 0.4 eV and is independent of crystal growth method, indicating that most of the carbon atoms are displaced from lattice nodes due to interaction with radiation defects rather than oxygen atoms. Neutron doping of silicon thus requires consideration of the behavior of both oxygen and carbon, radiation dose and reactor neutron spectrum. References 9: 4 Russian, 5 Western.

6508/12955
CSO: 1842/270

UDC 546.28

INFLUENCE OF TRANSIENT CRYSTALLIZATION MODES ON SILICON MICRODEFECTS

Moscow NEORGANICHESKIYE MATERIALY in Russian Vol 22, No 8, Aug 86
(manuscript received 25 Oct 84) pp 1237-1242

[Article by N. I. Puzanov and A. M. Eydenzon, Podolsk Chemical-Metallurgical Plant]

[Abstract] Dislocation-free silicon single crystals 40 mm in diameter with [111] growth axis were obtained by drawing from a pedestal in an atmosphere of Ar+H_2 at 1100-1200 GPa, H_2 concentration 4-8 vol.%. The crystals were doped with P; the [O] and [C] concentration did not exceed 10^{16} cm^{-3}. Microdefects were determined by copper decoration in combination with X-ray diffraction microradiography. It was found that the crystal growth rate varied smoothly over a period of 3-7 minutes from the steady value corresponding to the rate of withdrawal to 0 when withdrawal is stopped. The time of the transient process is greater in the center of the crystal than at the edges. Extending the time of stopping of withdrawal to over about 1 minute results in the appearance of A-defects, resulting from a decrease in the crystallization rate. The formation of these defects begins at 1470 K. References 11: 4 Russian, 7 Western.

6508/12955
CSO: 1842/272

UDC 536.7:546.47'48'18

THERMODYNAMIC PROPERTIES OF $Zn_xCd_{1-x})_3P_2$ SOLID SOLUTIONS

Moscow NEORGANICHESKIYE MATERIALY in Russian Vol 22, No 8, Aug 86
(manuscript received 1 Nov 84) pp 1243-1247

[Article by E. M. Smolyarenko and V. M. Trukhan, Solid State and Semiconductor Physics Institute, Belorussian Academy of Sciences]

[Abstract] A study is presented of the thermodynamic properties of $(Zn_xCd_{1-x})_3P_2$ solutions by the method of electromotive forces. Microstructural and X-ray analyses of annealed alloys in the range of compositions studied showed that there is ZnP_2-Cd_3P_2 phase equilibrium and all specimens of the solid solutions are in equilibrium at the experimental temperatures with monoclinic ZnP_2. It was found that at temperatures close to the solidus line the values of ΔG were small, indicating slow formation of $(Zn_xCd_{1-x})_3P_2$ solid solutions form the melt. This is particularly true of compositions rich in Cd_3P_2. The negative value of formation entropy discovered is explained by the more nearly perfect structure of the solid solution and by changes in the spectrum of thermal oscillations. It is shown that the solid solution is unstable at about 1000 K. References 8: 6 Russian, 2 Western.

6508/12955
CSO: 1842/272

UDC 621.315.592

MAGNETIC PROPERTIES OF $Zn(P_xAs_{1-x})_2$ ALLOYS

Moscow NEORGANICHESKIYE MATERIALY in Russian Vol 22, No 8, Aug 86
(manuscript received 15 Nov 84) pp 1248-1250

[Article by Ts. V. Vitkina, E. M. Smolyarenko and V. M. Trukhan, Solid State and Semiconductor Physics Institute, Belorussian Academy of Sciences]

[Abstract] The magnetic susceptibility of $Zn(P_xAs_{1-x})_2$ solid solutions was studied in a vacuum of about 10^{-3} Pa in fields of varying intensity up to 10^6 A/m at 170-570 K with an error of not over 2.5%. All of the alloys studied were diamagnetic. No traces of paramagnetic or ferromagnetic impurities were found. The structure of $Zn(P_xAs_{1-x})_2$ solid solutions was found to gradually convert to the structure of $ZnAs_2$ as x varied from 1 to 0. References 4: 3 Russian, 1 Western.

6508/12955
CSO: 1842/272

UDC 537.311:536.423.15

PRESSURE OF PHOSPHORUS AND ARSENIC VAPORS OVER INDIUM-ENRICHED MELTS IN THE SYSTEM Ga-In-P-As

Moscow NEORGANICHESKIYE MATERIALY in Russian Vol 22, No 8, Aug 86
(manuscript received 24 Oct 84) pp 1251-1254

[Article by A. A. Selin, A. G. Karamov and A. S. Malkova, Moscow Electronic Technology Institute]

[Abstract] A study was performed to determine the partial pressures of phosphorus and arsenic vapors over melts in the system Ga-In-P-As in the temperature interval characteristic for homogenization of the liquid phase and epitaxial growth (923-973 K). The partial pressures of the vapors were found by monitoring the loss of charge mass during evaporation in a flow of hydrogen carrier gas passing through special capillary gaps. The possibility was estimated of a change in the composition of the crystallizing solid solution due to evaporation of phosphorus and arsenic from the liquid phase. For the time interval of homogenization normally used with relatively small initial charges of about 1 g it was found that only at 973 K is there significant phosphorus and arsenic loss, leading to a measurable change in composition of the crystallizing solid solution with respect to the liquid solution. Introduction of slight excess quantities of phosphorus and arsenic can eliminate this change. References 13: 5 Russian, 8 Western.

6508/12955
CSO: 1842/272

UDC 621.382:546.21

SATURATION AND NEGATIVE DIFFERENTIAL RESISTANCE IN VOLT-AMPERE CHARACTERISTICS OF CdSe FILM PHOTOCURRENT

Moscow NEORGANICHESKIYE MATERIALY in Russian Vol 22, No 8, Aug 86
(manuscript received 23 Oct 84) pp 1259-1263

[Article by V. A. Smyntyna, Odessa State University imeni I. I. Mechnikov]

[Abstract] A study is made of the mechanism of development of the areas of saturation and negative differential resistance in the volt-ampere characteristics of cadmium selenide films considering the temperature-stimulated electron-molecular processes on the surfaces of the films. The volt-ampere characteristics were studied in the range of 10-600 V. Films used were 0.7-0.8 um thick, obtained by thermal atomization of powder onto an unheated substrate under a vacuum. The appearance of negative differential resistance and saturation on the volt-ampere curves is attributed to the formation of chemosorption-electrical domains stimulated by Joule heating of the films. Increasing specimen temperature decreases the power liberated in the specimen, activating chemosorption. A study of the volt-ampere characteristics in various atmospheres and at various wavelengths of illumination showed that these domains form on the surfaces of the specimens as a result of electron capture from the conductivity zone at the level of the chemosorbed oxygen, most intensively in the middle of the interelectrode gap where the temperature is greatest, leading to uneven distribution of resistance between the electrodes. References 13: 7 Russian, 6 Western (1 in Russian translation).

6508/12955
CSO: 1842/272

UDC 537.311.33

ELECTROPHYSICAL PROPERTIES OF Bi_2Se_3, Sb_2Te_3 AND Bi_2Te_3 MELTS

Moscow NEORGANICHESKIYE MATERIALY in Russian Vol 22, No 8, Aug 86
(manuscript received 15 Nov 84) pp 1264-1270

[Article by V. M. Glazov, V. B. Koltsov and V. A. Kurbatov, Moscow Electronic Technology Institute]

[Abstract] Experimental studies of the Hall effect, conductivity and thermal EMF were performed over a broad temperature range using a precision measurement method and highly sensitive apparatus in order to obtain reliable information on changes in concentration of charge carriers among Bi $Se_{2,3}$ Bi_2Te_3 and Sb_2Te_3 compounds. The method of measuring the Hall effect used is a modification of a compensation alternating current and variable magnetic field method described earlier. Analysis of the Hall effect results indicates that the Hall constant in the melts studied is negative and decreases monotonically in absolute value upon heating. The thermal EMF coefficient in

Bi_2Se_3, Bi_2Te_3 and Sb_2Te_3 has different signs. The nature of changes in the Hall constant and conductivity with increasing temperature indicates that the compounds act as semiconductors in the liquid phase. They are g-semiconductors according to the Mott classification. References 26: 15 Russian, 11 Western (2 in Russian translation).

6508/12955
CSO: 1842/272

UDC 621.3.049.75.002

OXIDATION OF MOLYBDENUM BORIDES UPON HEAT TREATMENT OF THICK FILM RESISTIVE COMPOSITIONS

Moscow NEORGANICHESKIYE MATERIALY in Russian Vol 22, No 8, Aug 86 (manuscript received 24 Oct 84) pp 1284-1287

[Article by O. N. Demin, L. Ya. Konyushenko, L. N. Lykova, M. V. Paromova and Z. Ya. Kulikova, Moscow State University imeni M. V. Lomonosov]

[Abstract] A study is presented of the oxidation of Mo B by oxygen of the air at various temperatures. The process is compared to oxidation of molybdenum boride performed in previous works by one of the authors and others. A study is also made of the interaction of molybdenum borides with aluminosilicate borobarium glass upon heating in air. Studies were performed on a functional phase, Mo_2B_5 or Mo_2B, and compositions of the functional phase plus glass. The phase compositions of the specimens were monitored by X-ray phase analysis. The most complete studies of oxidation of Mo_2B were performed at 600, 740, and 850°C. The X-ray phase analysis studies established that upon high temperature annealing of molybdenum boride plus glass in air the interaction product is MoO in contrast to annealing of Mo_2B specimens, where the major phase produced is metallic molybdenum. Aluminoborosilicate glasses do not interact with molybdenum borides upon high temperature annealing in air. References 7: 6 Russian, 1 Western.

6508/12955
CSO: 1842/272

UDC 539.216.2

GROWTH RATE AND PROPERTIES OF LAYERS OF AMORPHOUS CARBON OBTAINED IN A LOW-TEMPERATURE PLASMA

Moscow NEORGANICHESKIYE MATERIALY in Russian Vol 22, No 8, Aug 86
(manuscript received 28 Oct 83) pp 1288-1291

[Article by V. N. Polunin, P. P. Stanchula, A. A. Andreyev and B. T. Melekh, Physical Technical Institute imeni A. F. Ioffe, USSR Academy of Sciences]

[Abstract] A study is made of the growth kinetics and electrophysical properties of amorphous carbon films produced in the low-temperature plasma of an HF discharge and a DC discharge using benzene as the working gas. Experiments were performed on an industrial installation with a diode-type reactor. Argon was bubbled through the benzene vapors and the mixture fed into the reaction chamber, which contained 4% benzene. Studies were performed in the 1.3-70 Pa pressure range at 25-600°C substrate holder temperature. The carbon layers precipitated had semiconductor properties, similar in many ways to amorphous silicon synthesized by a similar method. At precipation temperatures below 310°C the films contained hydrogen. The precipitation rate and properties were found to depend on the technological parameters of the process, particularly the substrate temperature. The growth rate and index of refraction of the layers were greatly influenced by ion bombardment, type of discharge used and location of specimens on electrodes. References 9: 1 Russian, 8 Western.

6508/12955
CSO: 1842/272

UDC 539.216.2

INTERACTION OF GeO AND Al FILMS

Moscow NEORGANICHESKIYE MATERIALY in Russian Vol 22, No 8, Aug 86
(manuscript received 23 Oct 84) pp 1312-1314

[Article by Ye. G. Povolotskiy, V. Ya. Filipchenko and S. Kh. Finkelshteyn]

[Abstract] Results are presented from an experimental study of the interaction of GeO and Al films heat treated in air at 250-500°C. The system studied is widely used in constructing the anode plate of vacuum cathodeluminescent indicators. Phase changes in the films during heat treatment were recorded optically, by X-ray diffraction studies and electronographically. It was found that beginning at 400°C, zonal recrystallization of α-Ge occurred after breakdown of the GeO. Recrystallization on the free surface of the Al film and in its volume occurs by two different mechanisms: with the participation of the liquid phase and in a purely solid-phase mechanism. The structural and chemical exothermic conversions at the boundary between

GeO and Al in the Ge-Al system result in hypoeutectic contact melting. References 9: 7 Russian, 2 Western (1 in Russian translation).

6508/12955
CSO: 1842/272

UDC 546.431

STUDY OF INTERACTION OF BARIUM MONOGALLATE WITH BARIUM ALUMINATE

Moscow NEORGANICHESKIYE MATERIALY in Russian Vol 22, No 8, Aug 86 (manuscript received 24 Oct 84) pp 1351-1353

[Article by Z. R. Kadyrova, N. A. Sirazhiddinov and N. Rakhmanbekov, Chemistry Institute, Uzbek Academy of Sciences]

[Abstract] A study is presented of the interaction of barium monoaluminate with the alpha- and gamma-modifications of barium monogallate. Areas of existence of solid solutions formed on their basis in the system $BaAl_2O_4$-$BaGa_2O_4$ are determined. Carefully mixed oxides of stoichiometric composition were pressed into tablets which were then heat treated in an electric resistance furnace. $BaAl_2O_4$ and $BaGa_2O_4$ were synthesized at 1500°C for five hours. Finely dispersed powders of the compounds were then used to prepare a series of initial mixtures with compositions varied in steps of 5 mol.%, which were pressed into tablets, heat treated in air for five hours and then slowly cooled in air. Two types of solid solutions were formed. In the high temperature area, continuous solid solutions with hexagonal structure; in the low temperature area, limited solid solutions with rhombic structure based on the alpha-high temperature and gamma-low temperature polymorphous modifications of barium monogallate. References 3: all Russian,

6508/12955
CSO: 1842/272

UDC 546.654.431.31

PHYSICAL PROPERTIES OF $Ba_3LaTa_3O_{12}$ SINGLE CRYSTALS

Moscow NEORGANICHESKIYE MATERIALY in Russian Vol 22, No 8, Aug 86 (manuscript received 31 Oct 84) pp 1378-1383

[Article by V. A. Antonov, P. A. Arsenyev, Kh. S. Bagdasarov, A. A. Yevdokimiv, A. Ya. Neyman, Kh. G. Tadzhi-Aglayev, Moscow Power Engineering Institute]

[Abstract] The purpose of this work was to study certain optical and electrophysical properties of $Ba_3LaTa_3O_{12}$ single crystals obtained by vertical directed crystallization and optical zone melting. The compounds were synthesized by high temperature sintering of previously dehydrated $BaCo_3$, La_2O_3 and Ta_2O_5 of at least 99.99% purity. A charge of stoichiometric

composition was held at 1570-1620 K for 150 hours with triple intermediate grinding. Equilibrium of phase composition was monitored by X-ray studies. Vertical directed crystallization and optical zone melting were used to grow the single crystals. The dispersion of index of refraction was measured for both ordinary and singular rays and the Selmeier parameter was measured. The influence of high temperature annealing atmosphere on optical properties was studied and conditions of decoloration of crystals were selected for crystals obtained by vertical directed crystallization. The temperature variation of conductivity was studied and activation energies, values of dielectric permeability and dielectric loss angle tangent were determined. A physical model is suggested for the formation of defects responsible for color formation processes. References 9: 3 Russian, 6 Western (1 in Russian translation)

6508/12955
CSO: 1842/272

UDC 669.017.3

STRUCTURAL TRANSFORMATIONS IN 10R6M5 CAST STEEL POWDER DURING SWEATING

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 6, Jun 86 (manuscript received 30 Sep 85) pp 91-96

[Article by Yu. N. Taran, Ye. P. Kalinushkin, O. S. Yakushev, Ye. V. Arshava and V. D. Dashevskiy, Dnepropetrovsk Metallurgical Institute]

[Abstract] Compacting of powder high-speed tool steel under a pressure of 100 MPa at a temperature of 1150°C in a static argon atmosphere is facilitated by sweating at this near solidus temperature. For this reason, a study of the sweating process was made on 10R6M5 powder steel by the method of "stop-quenching" from the solid-liquid state. Specimens weighing 0.8 g were placed on an alundum substrate and heated in a stream of high-purity argon at a precisely controlled rate of 0.5 K/s to the eutectic point within the 1270-1300°C range, at which they were held for 600 s for subsequent quenching in aqueous 10% NaCl solution. Microstructural examination under optical and scanning electron microscopes as well as x-ray spectral microanalysis revealed an original dendritic solid solution with eutectic austenite-carbide interstices. The carbide phase (M_2C and thermodynamically more stable MC with higher vanadium content) was found to dissolve upon heating till complete liquefaction at 1270°C, at which temperature a high concentration of microspherical liquid droplets was found to have built up in the dendrites. No changes in the phase composition occurred within the 1270-1300°C temperature range, but at 1310°C there began a reverse peritectic transformation of austenite+liquid into δ-ferrite with a notable thin liquid metal interlayer at the δ-ferrite growth front but connecting to the interdendritic melt. A further study was made of the sintering process, with soaking at three critical temperatures (eutectic point 1270°C, peritectic point 1310°C, δ-ferrite dissolution point 1400°C) for 20 min at each and subsequent cooling in each case at a rate of 1 K/s (at which compact ingots weighing 450 kg are cooled from 1000°C with aqueous 10% NaCl solution in an industrial production process). Metallographical examination has revealed that long soaking at the eutectic point causes an appreciable buildup of eutectic carbides (M_2C, M_6C, MC) with formation of a weakly cooperative columnar structure during subsequent cooling, that sintering at 1310°C almost completely merges the powder grains but also facilitates growth of phase grains, and that soaking at 1400°C results in complete recovery of the cast

structure with grains of δ-phase solid solution surrounded by clusters of M_2C carbide lamellas and containing aggregate austenite-carbide inclusions. References 8: 5 Russian, 3 Western.

2415/12955
CSO: 1842/255

UDC 669.15.194:539.3.375

EFFECT OF LOW-TEMPERATURE THERMOMECHANICAL TREATMENT ON MECHANICAL PROPERTIES AND STRESS SENSITIVITY OF 03Cr11Ni10Mo2Ti STEEL

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 6, Jun 86 (manuscript received 12 Jul 84) pp 96-101

[Article by Yu. V. Bugrov, A. M. Bykov, A. P. Vlasov, R. I. Pylin and V. A. Skudov, Gorkiy Polytechnic Institute]

[Abstract] A study of 03Cr11Ni10Mo2Ti corrosion-resistant martensitically aging steel (0.0026% C, 10.8% Cr, 9.1% Ni, 1.89% Mo, 0.069% Ti, 0.023% Si, 0.011% Cu, 0.009% Al, 0.003% Mn) after low-temperature thermomechanical treatment was made, for the purpose of determining the effect of such a treatment on its mechanical properties and the sensitivity of its properties to a state of stress. Four modes of treatment were considered: 1) plain heat treatment by quenching from 860°C + soaking at the lower temperature for 1 h + air cooling; 2) plain heat treatment + plastic deformation by drawing to 17% reduction; 3) plain heat treatment + drawing to 0-15-35-60% reduction + aging of specimens in vacuum furnace at 530°C for 2 h + air cooling; 4) plain heat treatment + drawing to 0-15-35-60% reduction + aging of specimens in vacuum furnace at 580°C for 2 h + air cooling. Cylindrical specimens with a gage diameter of 4 mm, smooth ones and notched ones with 0.15, 0.6, 1.2, 2.5, 6.0 mm notch radii, were tested in tension at a deformation rate of $3.3 \cdot 10^{-5}$ m/s with an IM-12A machine and in impact at a velocity of 5.0 m/s with an MK-30 pendulum. Smooth specimens and M6 bolts were tested for fatigue under an asymmetrically alternating tensile stress at frequencies of 300 Hz and 0.33 Hz. Microstructural examination was done under an REM-100 scanning electron microscope. The results indicate that aging at 580°C increases the strength more than aging at 530°C, with prior 15% or 60% plastic deformation raising both yield strength and tensile strength more than prior 35% plastic deformation. They also indicate that the impact strength is increased by low-temperature thermomechanical treatment, aging at 580°C being more effective than aging at 530°C. Hardening and sensitivity to prestressing were evaluated on the basis of strength (stress-strain) and plasticity (percentage reduction) curves fitting the test data with semi-empirically determined power-law exponents. Calculations indicate that strength is more sensitive than plasticity and that aging at any of the two temperatures lowers the sensitivity of both to plastic predeformation. The results of both high-frequency and low-frequency fatigue tests by the "ladder" method on a 10^7 cycles life base indicate a higher fatigue limit for smooth cylindrical specimens after aging at 530°C than after aging at

580°C, and a lower fatigue limit for bolts hot upset and threaded prior to aging at the same temperatures. References 7: 6 Russian, 1 Western.

2415/12955
CSO: 1842/255

UDC 338.4:621.762

COMPARATIVE COST ANALYSIS OF VARIOUS METHODS OF IRON POWDER PRODUCTION

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 7, Jul 86 (manuscript received 25 Nov 85) pp 142-145

[Article by A. M. Polyak, Ye. K. Sivayeva, A. A. Klimchenkov, Ya. L. Gipsh and Ye. L. Frolikova, Moscow Steel and Alloys Institute]

[Abstract] The economics and cost effectiveness of producing iron powder by two methods are analyzed by following through all production stages from handling of bulk metal through reprocessing to delivery of commercial powder. Accounting covers cost of raw materials minus salvage value of tailings, cost of reprocessing (labor, energy, equipment maintenance+depreciation), and extra production costs as well as nonproductive overhead costs. The two methods of production compared on this basis are atomization of molten steel and reduction of iron sponge. Calculations based on data from several metallurgical plants (Brovary, Suleya, Novolipetsk and others) and current prices indicate that the first method is more economical, primarily because of a lower energy cost and fewer reprocessing stages, use of hydrogen on the other hand adding appreciably to the cost of the second method.

2415/12955
CSO: 1842/254

UDC 669.046.554

PROSPECTS FOR UTILIZATION OF FERROALUMINUM OBTAINED FROM LOW QUALITY ALUMINUM PRODUCTION WASTES

Moscow, TSVETNYYE METALLY in Russian No 8, Aug 86, pp 78-79

[Article by A. I. Sachko, N. I. Artemyev, O. P. Mikulyak, A. A. Baranov and V. I. Ladyanov]

[Abstract] Low quality aluminum wastes such as chips and slag can be utilized for the production of ferroaluminum. A charge consisting of the magnetic fraction from the processing of scrap and wastes and the oxide portion of aluminum slags was melted in an electric arc furnace, the melt produced was poured into a mold to produce 30x30 mm pieces of ferroaluminum. Pilot-scale testing of the ferroaluminum in deoxidation of steel was performed. Rolled products produced from the steel had good surface quality and indicated

good removal of both oxygen and nitrogen from the steel. The use of this deoxidizer therefore decreased the aluminum loss involved in the process and increased steel quality.

6508/12955
CSO: 1842/270

UDC 669.715.48

EFFECTIVENESS OF UTILIZATION OF EQUIPMENT FOR PROCESSING OF NONFERROUS METAL WASTE AND SCRAP

Moscow, TSVETNYYE METALLY in Russian No 8, Aug 86, pp 79-81

[Article by V. M. Chernobayev, A. D. Trifonova and S. S. Apanashchenko]

[Abstract] The VNIIP vtortsvetmet [possibly All Union Scientific Research and Planning Institute for Secondary Nonferrous Metals] has developed a method of determining the economic effectiveness of the utilization of individual types of scrap processing equipment at metallurgical enterprises, considering the annual productivity of the equipment, cost capital investments, calculated outlays per ton of raw materials, pay-off periods and profitability (as related to costs). This article describes the calculations involved in applying this method to be sure that expensive equipment is not installed in places where the flow of materials to be recycled is insufficient to justify the cost of the recycling equipment. Calculations are based on the standards of technological planning for production facilities for secondary nonferrous metals, the hourly productivity of the equipment, the standards for the number of basic production employees and basic wage rates, the value of fixed capital by types of equipment and the planned percentage of equipment down-time, standards for depreciation allowances by type of equipment, types and compositions of raw materials to be reprocessed and the energy resources required for the reprocessing. Calculations by the method allow determination of equipment attributes such as productivity, cost, area occupied, power consumption, servicing norms, etc. which are basic in the creation and utilization of new types of equipment.

6508/12955
CSO: 1842/270

UDC 669.715.48:65.011.54

SELF-PROPELLED CHIP CRUSHER

Moscow, TSVETNYYE METALLY in Russian No 8, Aug 86, pp 82-83

[Article by G. S. Kuzinets and A. A. Avdiyenko]

[Abstract] VNIIP vtortsvetmet has developed a self-propelled hydraulically controlled machine for crushing of curved aluminum chips for use in areas without hauling equipment. The new machine costs less to operate than stationary crushing machines. Tests were performed in several areas of the Vtortsvetmet plant at Mtsensk, crushing aluminum alloy chips with a high content of uncrushable objects to determine the technological capabilities of the device. Analysis of the fractional composition of the crushed chips indicated that maximum turn size is determined by the clearance between the blades of the precrushing gear shafts. The machine rolls on caterpillar-type tracks and is controlled by a single operator in a cabin. A drawing of the machine is presented.

6508/12955
CSO: 1842/270

UDC 621.762

PRODUCTS FROM POWDERS MANUFACTURED BY THE BROVARY POWDER METALLURGY PLANT

Moscow STAL in Russian No 8, Aug 86, pp 89-91

[Article by V. D. Pirog and K. A. Babaritskiy, Brovary Powder Metallurgy Plant]

[Abstract] The Brovary plant has developed several new products and manufacturing innovations. Machine, anti-friction, and soft-magnetic components are being produced from iron-based, sintered materials. The manufacturing technology includes mixing the charge, compacting and sintering. A mechanical-magnetic mixer is being used to mix groups Zh - ZhGr1 charges. The rest of the materials are prepared in two-screw mixers. Compacting and automated precision forging are done on hydraulic and mechanical automatic presses. A special conveyor-type sintering furnace designed to provide stable time and temperature parameters has resulted in considerable improvements in quality and the complete mechanization of sintering, which takes place in a medium of converted gas at 1040 - 1150°C. Technology for alloying iron powder from point sources has been adopted. Compositions containing alloying components have been put into use. Alloying compositions are being produced by atomization and thermal diffusion. Various compositions with iron powder bases are used with copper, phosphorous, nickel, chrome, molybdenum, etc. as alloying additives. A technological process including two compacting stages and intermediate and final sintering is used in the production of components with high densities (6.9 - 7.1 gr/cm^3). A special compacting

assembly consisting of three lower dies and three regulated charging chambers was developed for making combine components. Sintered electrode tape is a promising new material. Many different items are being produced from refractory compounds, titanium diboride and silicon carbide. Friction components with linings made from sintered materials are produced from grades MK-5, BMK-1, MK-403 and 263 tin-bronze based friction materials.

13050/12955
CSO: 1842/269

UDC 621.762.4

THE NATURE OF SULFUR LIQUATION DEFECTS IN HIGH-SPEED STEEL POWDER AND THE MECHANISM BEHIND THEM

Moscow STAL in Russian No 8, Aug 86, pp 91-93

[Article by A. N. Osadchiy, G. I. Parabina, V. N. Makogon, S. S. Kazakov and V. G. Kucherenko, Ukrainian Scientific Research Institute of Specialized Steels and the Dneprospetsstal Plant]

[Abstract] The effects of the sulfur content in the original metal, the temperature and speed of heating the powder before compacting, and the length of time the powder is held at high temperatures on the nature and severity of sulfur segregation was studied. Industrial grade powder melts (sulfur content by mass 0.015 - 0.03%) underwent statistical analysis, and experimental melts with low (0.003 - 0.012%) and high (0.10%) sulfur contents were prepared. Compacts were made in such a way as to cause sulfur segregation. It was found that sulfur segregation did not occur only when the sulfur content was 0.003 - 0.004% by mass, and was much more severe when the sulfur content was over 0.027%. Experiments in high-temperature heating and in forging the compacts after they were heated at various times and temperatures were conducted, and the effects of additional processing stages on the nature of the flaws were studied. Heating compact specimens with slight sulfur segregation at 1150°C produced larger sulfides and led to increased segregation. To impede sulfur segregation, powder must be heated before compaction at a rate of 20 - 30°/hr. and at a temperature not exceeding 1050 - 1075°C. To prevent increased sulfur segregation in heating compacts before deformation, the heating temperature should not exceed 1130°C for durations of 2 - 4 hours. An additional processing stage for billets with severe sulfur segregation (total deformation 60% and higher) make it possible to reduce the development of defects. References 1: Russian.

13050/12955
CSO: 1842/269

UDC 669.15'24'25'28-194:621.785:620.186.5

REGULATION OF STRUCTURIZATION PROCESSES IN MARTENSITICALLY AGING HIGH-STRENGTH STEELS BY HIGH-TEMPERATURE THERMOMECHANICAL TREATMENT

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 7, Jul 86 (manuscript received 31 Oct 85) pp 88-93

[Article by M. L. Bernshteyn, S. A. Voronin, A. B. Dolgin, A. F. Yedneral, L. M. Kaputkina, V. G. Prokoshkina and M. D. Perkas, Moscow Steel and Alloys Institute]

[Abstract] A study of four martensitically aging high-strength Ni-Co-Mo steels and their high-temperature thermomechanical treatment was made, its purpose being to determine the dependence of the structural state of hot-deformed austenite on the mode of treatment and to optimize the treatment for minimum grain size. Ingots of Ni17Co15Mo6Ti (6.3% Mo, 0.8% Ti), Ni16Co16Mo6Ti1.4 (6.3% Mo, 1.4% Ti), Ni10Co15Mo11 (10.9% Mo, 0.2% Ti), Ni10Co15Mo12 (12.3% Mo, 0.13% Ti) steels were austenitized at optimum temperatures for complete dissolution of the brittle μ-phase without excessive growth of the austenite grain and, accordingly, at 950°C (6.3% Mo), 1050°C (10.9% Mo), 1100°C (12.3% Mo), then hot rolled at 1000-800°C and water cooled. The microstructure after treatment was examined metallographically and strains were calculated according to a standard formula. Whether the resulting microstructure was found to be polygonized, recrystallized, or mixed was dependent on the rolling temperatures as well as on the Mo content. Adequate comminution of the grain evidently requires lowering the final deformation (rolling) temperature to 820-800°C for steels with 6.3% Mo and to 900-880°C for steel with 10.9% Mo. References 10: 5 Russian, 5 Western.

2415/12955
CSO: 1842/254

UDC 669.765'74-153.6:538.21

EFFECT OF ANNEALING ON MAGNETIC PROPERTIES OF EUTECTIC Bi-MnBi ALLOYS WITH GRAIN ORIENTATION

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 7, Jul 86 (manuscript received 10 Feb 86) pp 94-97

[Article by A. V. Zhuravlev, B. G. Livshits and Yu. V. Cheslya, Moscow Steel and Alloys Institute]

[Abstract] A study of eutectic Bi-MnBi alloys consisting of MnBi needles dispersed in a Bi matrix was made, to establish the dependence of grain orientation on the crystallization process and of phase equilibrium and magnetic properties on the subsequent annealing process at temperatures slightly below the melting point. Dependence on the temperature gradient during crystal growth was taken into consideration by growing crystals at as widely different temperature gradients as 200 K/cm and 50 K/cm. The crystallization rate was varied over the 0.5-145 cm/h range. Short annealing at 531 ± 1 K was done in a liquid-bath thermostat and long annealing at 523^{+2}_{-3} K was done in a furnace, specimens grown at a 200 K/cm temperature gradient being annealed for up to 700 h and specimens grown at a 50 K/cm temperature gradient being annealed for up to 384 h. Grain orientation was obtained by crystallization at rates of 19-72 cm/h at a 200 K/cm temperature gradient and at rates of 2-36 cm/h at a 50 K/cm temperature gradient, no grain orientation having been attained with higher crystallization rates. Magnetic properties were measured with a vibration magnetometer in a magnetic field of 2000 kA/m intensity, after magnetization of specimens in the magnetic field of an electromagnet with a maximum intensity of 2700 kA/m. Specimens were mechanically polished for microstructural examination under an optical microscope. Measurements have revealed a dependence of both the coercive force and the ratio of remanence after magnetization in field of 2700 kA/m intensity to magnetic induction in a demagnetizing field of 2700 kA/m intensity on the annealing time. These data as well as the measured mean distance between MnBi needles and mean needle diameter indicate that only long annealing for at least 384 h at 523-528 K will establish a phase equilibrium, without a decrease of the coercive force by attendant enlargement of MnBi grains under these conditions. The coercive thus appears not to be related to the amount of metastable phase in the alloys. The maximum coercive force at phase equilibrium was obtained by annealing at 526 K for 384 h after oriented crystal growth at a rate of 36 cm/h. References 9: 2 Russian, 7 Western (1 in Russian translation).

2415/12955
CSO: 1842/254

USE OF NONTRADITIONAL COOLING FLUIDS IN HEAT TREATMENT

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV No 10, Oct 86, pp 2-3

[Article by O. A. Bannykh]

[Abstract] The problem of optimizing the conditions of quenching of metal parts during heat treatment is an old one which is attracting new interest, since many parts need to be cooled at rates intermediate between those achieved in water and in oil, and because industrial oil is in short supply and dangerous in terms of fire. Many cooling fluids intended to replace oil in hardening have been suggested, including polymer solutions, monosulfite liquor and polyacrylamide. Further analysis of the properties of aqueous solutions of polymers and salts may result in the creation of new hardening fluids with great stability of cooling capacity in spite of changing temperatures and concentrations of additives.

6508/12955
CSO: 1842/9

UDC 621.78.063

NEW HARDENING FLUID BASED ON PK-2 POLYMERS

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV No 10, Oct 86, pp 3-6

[Article by V. Z. Annenkova, L. N. Zhdankovich, deceased, V. M. Annenkova, G. S. Ugryumova and M. G. Voronkov, Irkutsk Institute of Organic Chemistry, Siberian Department, USSR Academy of Sciences; Irkutsk State Pedagogical Institute]

[Abstract] A new aqueous polymer hardening fluid has been developed using the water-soluble polymer PK-2, an iron-containing polyacrylic acid composition, which is a yellowish-brown vitreous substance that is soluble in water, odorless, and has a molecular mass of $5 \cdot 10^5$ - $2 \cdot 10^6$. Cooling curves of the substance were measured under static and circulating conditions, using silver ball sensors heated to 800°C. The influence of initial bath temperature on cooling capacity and usage life of PK-2-based cooling fluids were studied. Special studies indicated that a replenishing solution consisting of 30% of the initial 1% neutralized PK-2 solution and 70% tap water could be used to maintain cooling capacity of quenching solutions. The actual composition of replenishing solutions must vary, since evaporative loss from the solution is pure water, while PK-2 is carried away with the parts hardened in varying quantities depending on surface complexity and roughness. References 3: all Russian.

6508/12955
CSO: 1842/9

UDC 621.78.063

INFLUENCE OF VARIOUS FACTORS ON COOLING CAPACITY OF PK-2 POLYMER-BASED QUENCHING MEDIUM

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV No 10, Oct 86, pp 6-9

[Article by L. N. Zhdankovich, deceased, V. Z. Annenkova, V. M. Annenkova, G. S. Ugryumova and M. G. Voronkov, Irkutsk Institute of Organic Chemistry, Siberian Department, USSR Academy of Sciences; Irkutsk State Pedagogical Institute]

[Abstract] The cooling rate of PK-2-based quenching solutions can be varied by changing the concentration of the polymer, changing the mean rate of relative movement of part and medium by bubbling or agitation, and by adding sodium chloride. The article discusses the influence of these methods on the cooling rate of PK-2 solutions. The results of the study indicate that PK-2 has an advantage over other possible quenching media. Further studies will result in the development of other media such as PK-3 for hardening of carbon tool, ball bearing and spring steels.

6508/12955
CSO: 1842/9

UDC 621.78.063

COOLING PROPERTIES OF AQUEOUS SOLUTIONS OF PK-2 POLYMER

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV No 10, Oct 86, pp 16-19

[Article by G. Ye. Zvigintseva, N. L. Nikolayeva and Yu. G. Eysmondt, Central Scientific Research Institute of the Technology of Heavy Machine Building, (TsNIITtyazhmash)]

[Abstract] Results are presented from studies of the cooling capacity of aqueous solutions of PK-2 polymer. The solutions are neutralized with NaOH to pH = 8. The cooling capacity of the solutions depends on the polymer content and the hardness of the water used to prepare the solutions. Increasing the temperature or adding sodium alkylsulfate or other water softening agents such as polycomplexon IOMS-1 or oxyethylidene diphosphonic acid increases the interval of film cooling and thus decreases the cooling capacity of solutions. References 3: all Russian.

6508/12955
CSO: 1842/9

UDC 621.78.063

HARDENING PROPERTIES OF AQUEOUS SOLUTIONS BASED ON PK-2 POLYMER

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV No 10, Oct 86, pp 19-21

[Article by G. Ye. Zvigintsyeva, N. L. Nikolayeva and Yu. G. Eysmondt, Central Scientific Research Institute of the Technology of Heavy Machine Building (TsNIITtyazhmash)]

[Abstract] The hardening capability of PK-2 polymer media as studied by the "H" factor method using 2-stage specimens of 40Kh steel. A medium containing up to 1.4% of the polymer was found to have hardening capacity between that of water and of oil. Specimens of various shapes and sizes were used to study the crack formation tendency of specimens hardened in the polymer. Crack formation tendency was found to be higher after hardening in PK-2 than in oil, due to the nonuniformity of the polymer solutions and the more rapid cooling of parts in the lower temperature interval. Cooling in aqueous PK-2 solutions may result in "reverse" hardening of steels. Bubble mixing of PK-2 media decreases the hardenability of steels. References 5: 3 Russian, 2 Western (1 in Russian translation).

6508/12955
CSO: 1842/9

UDC 621.78.063

NEW UZSP-1 POLYMER HARDENING MEDIUM

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV No 10, Oct 86, pp 29-31

[Article by K. D. Rusov and S. G. Yedemskiy, Yarsolavl Motor Plant]

[Abstract] A team has been set up at the authors' plant to develop a polymer additive for aqueous hardening media to reduce the crack formation tendency of parts hardened in water. The additive must meet the following requirements: 1) not greatly reduce the cooling rate during the initial stage of hardening; 2) allow variation of mean cooling rate between that of water and that of oil; 3) allow universal use; 4) not precipitate sediment onto the surface of parts hardened; and 5) allow large-scale production of the hardening medium from inexpensive and available materials using existing equipment. A new polymer additive called UZSP-1 has been developed which basically satisfies these requirements. The article reports on quench-hardening tests of various sample parts using the new medium, the composition of which is not given. The use of UZSP-1 to replace oil allows manufacture of parts made of less expensive steels. Aging of a solution of UZSP-1 for two years did not cause any change in its hardening properties.

6508/12955
CSO: 1842/9

UDC 665.767:621.22/9(088.8)

CREATION AND USE OF SPECIAL HARDENING OILS

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV No 10, Oct 86, pp 40-42

[Article by N. Ya. Rudakova, B. K. Sheremeta and T. I. Tkachuk, VNIIPKneftekhim]

[Abstract] Oils developed at the authors' institute for hardening of metals since 1973 are noted. These include the MZM series of oils which were developed in 1973 and are widely used at over 60 industrial plants; the special light hardening oil MZM-B with increased cooling capacity, produced by mixing industrial oil with an additive based on C_{20} and higher synthetic fatty acids; VZ-1 oil for vacuum hardening, with elevated cooling capacity, antioxidation stability and low vapor pressure, relatively low viscosity and high boiling point and equal in its properties to H-2 oil produced in the U.S.A.; and MGZ oil for multistage hot quenching, with high antioxidation stability and the necessary cooling capacity, relatively low viscosity and high flash point. References 3: 2 Russian, 1 Western.

6508/12955
CSO: 1842/9

UDC 621.791.755:669.71

PLASMA-ARC WELDING OF ALUMINUM ALLOYS WITH CONSUMABLE ELECTRODE

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 5, May 86 pp 1-2

[Article by Yu. D. Shchitsyn, engineer and Yu. M. Tytkin, Perm Polytechnic Institute]

[Abstract] Considering that a torch with annular anode and a consumable electrode is most efficient for plasma-arc welding, such a torch has been developed and built by the authors for welding aluminum alloys in a UPS-501 machine using a VSVU-630 or VDU-504 plasma-arc power supply with dropping or stiff load characteristic respectively. Its performance is reliable over the 60-250 A range of plasma-arc current and the 0-350 A range of consumable-electrode current. Its special features are replaceability of the anode ring and the stabilizer nozzle during operation, also an adjustment mechanism for precise alignment of the consumable electrode coaxially with the plasma arc. Argon is the plasma forming gas, stabilizing gas, and shielding gas, a stable welding process and high-quality welding seams requiring argon rates of 2-5 l/min, 4-8 l/min, and 5-9 l/min respectively. The torch was tested on 5 mm thick plates of AlMg2-M alloy, with a wire 1.6 mm in diameter of the same material as consumable electrode. Inspection of joints by x-radiography revealed an almost zero porosity. Without separation of edges, the welding speed can be made 1.5-2 higher with this than with a conventional plasma-arc torch and it is feasible to weld together plates up to 14 mm thick in a single pass. References 3: all Western.

2415/12955
CSO: 1842/260

UDC 621.791.927.55:669.15

DEPENDENCE OF LAYER BUILDUP ON STEEL DURING PLASMA-ARC HARD FACING WITH POWDER ON POLARITY OF ARC CURRENT

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 5, May 86 pp 2-4

[Article by M. M. Ermantraut, candidate of technical sciences and V. A. Komarov, engineer, Krasnoyarsk Polytechnic Institute]

[Abstract] Hard facing of carbon steel with wide and thin layers by plasma-arc treatment of Fe-alloy or Ni-alloy powder was studied, for the purpose of determining the dependence of layer buildup with minimum penetration into the base metal on the polarity of the arc current. Plates of hot-rolled St3 carbon steel were hard faced with PG-S1 Fe-alloy powder and with PG-SR4 Ni-alloy powder, at the same speed of 5 m/h and with the same powder consumption of 2.3 kg/h in each case. The amplitude of vibrations at a frequency of 0.9 Hz was 11 mm, and the treated plate surface was 9 mm away from the plasmatron. First, by gradual increase of the arc current from a very low level in forward and reverse directions, the minimum arc current of each polarity necessary for producing a smooth continuous face layer was established, whereupon the current was increased further in 10 A steps. The hardness of the face layer and the volume fraction of steel particles in it were measured after treatment at each current level for determining the relation between these two layer characteristics and the dependence of the penetration depth into steel on the magnitude of the arc current of either polarity. The results indicate that an arc current of either polarity can produce a high-quality face layer, but that its penetration depth into the steel is 1.7-3.4 times smaller with a current of forward polarity. While the thermal efficiency is lower with a forward current, the arc is more stable with a forward current and the cathode spot does not stabilize at all relative to the heating spot with a reverse current. References 2: both Russian.

2415/12955
CSO: 1842/260

UDC 621.791.755

PLASMATRON FOR PLASMA-ARC WELDING WITH AXIAL FEED OF ELECTRODE WIRE

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 5, Mar 86, pp 6-7

[Article by V. L. Ronskiy, engineer, V. D. Forgel, engineer, Rostov Scientific Research Institute of Machine Building Technology and B. L. Bozhenko, candidate of technical sciences, Volgodonsk branch of Novocherkassk Polytechnic Institute]

[Abstract] A plasmatron for automatic plasma-arc welding has been developed and built with an axial feed of the electrode wire. It operates with an

arc current of reverse polarity, to ensure a stable arc and a deep fusion zone. Cathode sputtering is more intense than with an arc current of forward polarity, an important consideration for welding aluminum alloys, but a tungsten electrode is not very stable and has been replaced with a nonconsumable copper or graphite anode ring. Argon gas is used for shielding the anode region of the arc aginst inrush of air, for stabilizing the arc, and for shielding the arc in the welding zone against ambient air. The laboratory prototype of this plasmatron was tested in butt-welding 2-8 mm thick parts of corrosion-resistant steel as well as 4-10 mm thick parts of aluminum alloys and of copper alloys. Hard facing with this plasmatron for buildup of worn surfaces should have an economic effect worth 29,400 rubles annually.

2415/12955
CSO: 1842/260

UDC 621.791:621.791.92

PLASMA-ARC REMELTING OF SURFACE OF EQUIPMENT PARTS FOR BETTER WELDABILITY IN REPAIR AFTER EXPOSURE TO ATMOSPHERE CONTAINERS H_2S

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 5, May 86, pp 8-10

[Article by O. I. Steklov, doctor of technical sciences, A. V. Alekseyev, candidate of technical sciences and V. F. Ivanov, engineer, Moscow Institute of Petrochemical and Natural Gas Industry imeni I. M. Gubkin]

[Abstract] A method of repairing equipment after exposure to H_2S has been developed at the Institute of Petrochemical and Natural Gas Industry which essentially involves desulfurization of the metal surfaces by remelting them with a plasma arc in an Ar+ O_2 atmosphere prior to rejoining the parts with a welding seam. The plasma arc generates a chemically active atmosphere in which sulfur, first vaporized and then driven outward by the argon, combines with the oxygen into SO and SO_2 which then escape. The pressure of saturated sulfur vapor above the metal surface depends on the process temperature only, provided that no phase transformations occur in the solid state, and the maximum S, SO, SO_2, S_2O yield is attainable at 2500-3000°C depending on the degree of surface contamination. The most likely mechanism of sulfur vaporization is interdiffusion of gaseous and liquid phases with attendant movement of sulfur atoms. Measurement of the depthwise temperature profiles in the base metal has yielded a diffusion coefficient ranging from $8.21 \cdot 10^{-10}$ to $1.3 \cdot 10^{-3}$ m^2/s at temperatures of 1000 to 2800°C respectively. Chemical and phase analysis of St20 carbon steel, 20Al black-annealed steel, 09Mn2Si and other alloy steels has revealed an about 60 μm wide decarburization zone near the transition layer but no depletion of alloying elements after remelting, then fine-grain and coarse-grain ferrite and pearlite zones in a welded joint. References 4: all Russian.

2415/12955
CSO: 1842/260

UDC 621.791.001.669.715

SOME WELDABILITY CHARACTERISTICS OF PRESSED STRIPS OF 1201 ALUMINUM ALLOY

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 5, May 86, pp 10-12

[Article by V. I. Ryazantsev, candidate of technical sciences, Yu. I. Tolkachev, engineer, G. A. Slavin, doctor of technical sciences, A. S. Roshchina, engineer and G. V. Gvadzabiya, engineer]

[Abstract] Arc welding of pressed strips of 1201 aluminum alloy was studied for the purpose of determining and evading the causes of their poor weldability. Large ingots of this alloy were annealed, whereupon blocks 120x260x500 mm^3 in size were cut out. These were quenched and artificially aged before being further cut into 6 mm thick plates 110x450 mm^2 in cross-section, either along or across the fiber. Plates were stacked for welding along edges either parallel or perpendicular to the fibers, in the direction of pressing, and also for welding across edges. Welding was done manually with an alternating argon-arc current of symmetric waveform and automatically with a direct helium-arc current of forward polarity. Only welded joints with nondefective continuous seams were tested mechanically. Macrochemical analysis before and after welding revealed a redistribution of the 5.0-6.0% Cu into alternating zones of high and low Cu content with 25-35% Cu maxima and 0.8-1.5% Cu minima respectively, corresponding respectively to bright and dark bands on x-radiograms. The results indicate that the mechanical characteristics of such welded joints depend on the direction of the fiber relative to the cut and the direction of welding. Welding along edges perpendicular to the fiber yields strongest and most stable joints. Welding along edges parallel to the fiber or across edges yields joints whose mechanical characteristics depend on the geometry and are best when far away as possible from the outside surface. References 5: all Russian.

2415/12955
CSO: 1842/260

UDC 621.791.3.01

PHYSICOCHEMICAL PROCESSES DURING DIFFUSION BRAZING OF NIOBIUM WITH TITANIUM, ZIRCONIUM, OR VANADIUM SOLDER AND PARAMETERS OF BRAZING OPERATION

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 5, May 86, pp 16-17

[Article by V. L. Grishin, candidate of technical sciences and S. V. Lashko, doctor of technical sciences]

[Abstract] Diffusion brazing of Nb with Ti, Zr, or V solder and the attendant physicochemical processes were studied, interaction of Nb with the solder metal and the resulting seam characteristics being of particular concern. Specimens of commercially pure Nb, 2-4 mm thick, were heated by the electrical-resistance method and by radiation in a furnace under a vacuum of $6.6 \cdot 10^{-3}$ Pa.

They were held 1-15 min at temperatures of 1750°C, 1900°C, and 1950°C for brazing with Ti, Zr, and V respectively. The distribution of Ti, Zr, V across the brazing seam and its dependence on the width of gap between Nb edges were determined in an MAR-1 35 kV x-ray spectral microanalyzer. The respective diffusion coefficients were calculated from the subsequently plotted concentration curves, all peaking at the center of the seam. The results of microhardness measurement as well as those of metallographical examination and x-ray phase analysis indicate the mode of crystallization after heating and cooling at various rates as well as, depending on the length of holding (brazing) time, the necessary length of subsequent homogenizing heat treatment at a temperature below the secondary-recrystallization point. References 3: 2 Russian, 1 Western.

2415/12955
CSO: 1842/260

UDC 621.791.3.042

SOLDER MADE OF Fe-Ni-Cr-Si-B POWDER ALLOY

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 5, May 86, pp 24-25

[Article by M. I. Chikunov, candidate of technical sciences, I. V. Kuznetsov, engineer, N. G. Kartyshov, candidate of technical sciences, A. F. Slyunyavchikov, engineer, R. P. Shchegoleva, candidate of technical sciences and V. N. Plechev, candidate of technical sciences]

[Abstract] A new solder has been developed for brazing together parts of structural steel which has a lower melting point than those of existing solders and is much more economical in terms of scarce metals. It is made of a Fe-Cr-Ni-Si-B powder alloy and contains no Mo and Co, the optimum composition being 40% Fe+ 40% Ni+12% Cr+ 6% Si+ 2% B with the Ni content much lower than in existing solders for this application. Its melting point is within the 1410-1440 K range. It has been tested in joining flat 1 mm thick parts of 12Cr18Ni10Ti steel and of 12Cr25Ni16-Mn7N_2B steel with 0.1-0.5 mm wide gaps between edges, ultimate tensile strength of the joint at room temperature (293 K) and at high temperatures (973 K, 1173 K) being the performance criterion. Distribution of Fe,Cr,Ni,Si in the base metal and in the seam was determined in an MAR-2 x-ray spectral microanalyzer. Microstructural and phase analysis under an electron microscope with single-stage carbon extraction replicas revealed formation of borides $(Cr,Fe,Ni)_2B$, carbides $(Cr,Fe,Ni)_{23}C_6$, and aluminosilicates. Brazing at temperatures above the melting point up to 1493 K was found to cause erosion of the steel and to produce a weaker joint. References 2: both Russian.

2415/12955
CSO: 1842/260

UDC 621.791.04:621.3-523.8

SOFTWARE FOR COMPUTER-AIDED DESIGN OF ROUTE-FOLLOWING TECHNOLOGICAL PROCESSES IN PRODUCTION OF WELDED STRUCTURES

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 5, May 86, pp 36-38

[Article by V. Ye. Krivosheya, Lipetsk Polytechnic Institute]

[Abstract] A system of computer-aided design of route-following technological processes is being developed for production of welded structural assemblies. A "generalized" route has been established first, such a route representing a standard solution of the design problem for small-scale or medium-scale production, the example given being specifically applicable to assembly of T-40 tractors at the Lipetsk Tractor Manufacturing Plant. The route defines both the content and the sequence of operations. The algorithm of computer-aided design starts with specification of either structure parameters and process route contour by the manufacturing engineer or specification of the route graph, there being correspondingly two possible modes of input data input. It continues according to a program, the basic design method, or in the dialog mode, or by sampling the records pertaining to an analogous already-designed technological process. All input data, intermediate data, and welding or other reference data are properly encoded for either form of input. The program package SAPRMT in PL/1, available for computer-aided design by the basic method, has been optimized in FORTRAN-4 for use on YeS Unified System computers and adapted for assembly of welded structures in flexible production system. References 5: all Russian.

2415/12955
CSO: 1842/260

UDC 621.791.72.052:669.295'71'292-413:620.17

STRENGTH OF JOINTS PRODUCED BY ELECTRON-BEAM WELDING OF PARTS MADE OF Ti-(Al,V) ALLOY

Kiev AVTOMATICHESKAYA SVARKA in Russian No 7, Jul 86
(manuscript received 21 Jun 85, in final version 1 Oct 86) pp 38-41

[Article by V. A. Gladkovskiy, doctor of technical sciences, N. N. Vasserman, candidate of technical sciences, I. S. Fatiyev, candidate of technical sciences, Yu. P. Smetannikov, candidate of technical sciences, N. I. Nikitin, engineer and V. A. Subbotin, engineer, Perm Polytechnic Institute]

[Abstract] Joints produced by electron-beam welding of parts made of a Ti-Al-V alloy were tested for mechanical properties at room temperature in air, 40 mm thick plates of this alloy having been welded together under vacuum in a single pass at a rate of 18 m/h. Tension tests performed on 10 type-I No 2 specimens, with the welding seam in the middle of a specimen and with fracture occurring consistently in the parent metal, indicate that

such joints are stronger than the parent metal. Fatigue tests performed on smooth specimens under a flexural load reversing at a frequency of 50 Hz and increased stepwise indicate, according to the Weibull probability distribution, a 10^7-cycles fatigue limit of such welded joints approximately 35% lower than that of the parent metal. Microstructural examination under an MIM-8M optical microscope and an REM-200 scanning electron microscope revealed an α -phase only: equiaxial grains of the 0.1-0.3 mm size fraction along the seam axis, finer grains at the periphery, and columnar grains of the 2 mm size fraction in the region between. Standard microhardness measurement with a PMT-3 tester and 1 N load revealed no regular variation of microhardness across the joint and thus no structural or phase transformation in the softening zone. Stress analysis indicates that not only plastic deformation but also concentrated residual tensile stresses outside the seam zone are responsible for the low fatigue limit of such joints. Annealing at 650,880,950°C for 2 h and subsequent air cooling raised the fatigue limit of joints to almost that of the base metal, 650°C being the optimum annealing temperature for also raising their tensile strength. References 13: 11 Russian, 2 Western (both in Russian translation).

2415/12955
CSO: 1842/257

UDC 621.791.927.048:(621.791:669.14.018.8).002.5:621.039

FLUXES FOR ELECTRIC-ARC HARD FACING OF ANTICORROSIVE COATINGS ON EQUIPMENT IN NUCLEAR POWER PLANTS WITH ELECTRON TAPE

Kiev AVTOMATICHESKAYA SVARKA in Russian No 7, Jul 86
(manuscript received 3 Apr 85, in final version 26 Jul 85) pp 52-54

[Article by Yu. V. Bobrikov, candidate of technical sciences and B. A. Merkulov, candidate of technical sciences, Atomkotlomash Scientific-Production Association, Rostov-na-Donu]

[Abstract] Fourteen available fluxes have been evaluated for use in hard facing of anticorrosive coatings by the electric-arc process with electrode tape, particularly coatings of Cr-Ni stainless steel on pearlitic structural steel, this process having already been mechanized for reactor equipment in nuclear power plants. These fluxes contain various combinations of metal oxides and fluorides, most of them in fused form (one flux, produced by a Swedish manufacturer, in ceramic form). Their chemical activity, the measure of their oxidizing power, was calculated from the concentrations of oxides according to the applicable N. N. Potapov formulas. Their performance was tested with Sv-07Cr25Ni13 and Sv-04Cr20Ni10Mn2Nb welding electrode tape on steel containing δ-ferrite. Most suitable is OF-10 flux (35-46% CaF_2, 28-34% Al_2O_3, 11-14% MgO, 9-12% SiO_2, 8% CaO, 1% Fe_2O_3, 0.3% MnO) for hard facing at a rate of 0.33 cm/s with a welding current of 650-700 A at 34-36 V, but FTs-18 flux (CaO-MgO-Al_2O_3-SiO_2 slag and Cr_2O_3 + NaF) with a 300 K lower hardening temperature is also recommended as alternative or replacement for hard facing at the same rate of 0.33 cm/s with a welding current of 700-750 A at 30-32 V. References 8: 7 Russian, 1 Western.

2415/12955
CSO: 1842/257

UDC 621.791.052:669.245.018.44:620.17

MECHANICAL PROPERTIES OF JOINTS PRODUCED BY ARGON-ARC AND LASER-BEAM WELDING OF PARTS MADE OF CrNi45MoWTiAlNb-R ALLOY

Kiev AVTOMATICHESKAYA SVARKA in Russian No 7, Jul 86
(manuscript received 27 May 85) pp 65-66

[Article by L. I. Sorokin, candidate of technical sciences and V. I. Tupikin, engineer, Moscow]

[Abstract] Joints produced by argon-arc and laser-beam welding of parts made of CrNi45MoWTiAlNb-R alloy were tested for mechanical properties, 2 mm thick plates of this alloy having been welded together, some after quenching and others after quenching+aging. The joints of plates only quenched before welding were quenched from 1080°C in air and aged in air for 5 h at 780°C + 10 h at 650°C. The joints of plates quenched and aged before welding were not heat treated. Laser-beam welding was done in a TL-10 machine with a 130 mm depth of focus and an Ar-He gaseous shield. Argon-arc welding was done in an ADS-1000 automatic machine with a tungsten electrode without filler. Metallographical examination and microhardness measurement have revealed that both the fusion zone and the heat-affected zone become narrower as the welding speed is increased, attendant structural transformations occurring more intensely during laser-beam welding. Mechanical tests revealed a dependence of the tensile strength on the heat treatment and on the welding speed. Quenching and aging of a joint were found to increase its tensile strength to approximately that of the parent metal at room temperature and to only slightly below that at 650°C. Evidently quenching dissolves excess phases within the heat-affected zone and aging precipitates the principal hard γ'-Ni (Al,Ti) phase. Increasing the welding speed increase the strength of a joint slightly at 20°C and at 650°C in the case of argon-arc welding, but only at 20°C in the case of laser-beam welding, this being evidently related to narrowing of the region of γ'-phase precipitation and to additional aging during tests at 650°C. References 4: all Russian.

2415/12955
CSO: 1842/257

UDC 621.791.052:669.295:539.374

PLASTICITY OF WELDED JOINTS OF OT-4 Ti ALLOY AT 77 K TEMPERATURE

Kiev AVTOMATICHESKAYA SVARKA in Russian No 7, Jul 86
(manuscript received 19 Nov 85, in final version 27 Jan 86) pp 66-67

[Article by A. D. Levitskaya, engineer and Yu. A. Shalimov, candidate of technical sciences, Lvov Polytechnic Institute imeni Lenin Komsomol]

[Abstract] A comparative evaluation of welded joints of OT-4 titanium alloy was made, for the purpose of determining the effect of welding by various

methods on their plasticity at 77 K temperature. Argon-arc welding was done with a local shield (11 m/h - 100 A, 21 m/h - 165 A, 10-11 V), in a controlled atmosphere with $6.5 \cdot 10^{-2}$ Pa residual pressure (21 m/h - 155 A, 30 m/h - 187 A, 10-11 V), and with pulses of 0.20-0.16 s duration (21 m/h - 332 A - 11 V, 21 m/h - 390 A - 10 V). Electron-beam welding was done under vacuum at speeds of 21, 28, 40 m/h. Specimens, 55 mm long and 10x2 mm^2 in cross-section, were cut across the welding seam and tested under a flexural load at a deformation rate of 2 mm/min in a UMM-5 machine with a chamber containing liquid nitrogen. Load-deflection curves were recorded by a PDP-4 XY-plotter for monitoring the initiation of cracks. The results indicate that, while the plastic deformation of such joints at room temperature does not significantly depend on the mode of heat supply during welding, at 77 K temperature a joint bends less than the parent metal. The bending angle of a joint at 77 K depends on the welding process, maximum plasticity of a joint being attained by argon-arc pulse welding with a tungsten electrode at a speed of 21 m/h. References 3: all Russian.

2415/12955
CSO: 1842/257

UDC 621.791.3.052:620.193.2:535-31

STRESS CORROSION OF SOLDERED JOINTS IN ULTRAVIOLET LIGHT

Kiev AVTOMATICHESKAYA SVARKA in Russian No 7, Jul 86
(manuscript received 10 Oct 85, in final version 15 Feb 86) pp 70-71

[Article by R. S. Luchkin, candidate of technical sciences, S. Kh. Peteraytis, candidate of technical sciences and L. I. Lomakina, engineer, Tolyatti Polytechnic Institute]

[Abstract] Stress corrosion of soldered joints in sea water was studied, joints connecting parts made of M3 copper of MNZhMts30-1-1 copper alloy being at the same time mechanically stressed and irradiated with ultraviolet light. The light source, a PRK-7 lamp with special reflector, was placed sufficiently high above the electrochemical test cell as not to raise the temperature inside above the normal 293±3 K level. The electrode potential, measured accurately within ±1 mV, served as indicator of the surface corrosion level. The mechanical load was measured accurately within ±3 kN. Tests performed on eight copper specimens and eight alloy specimens, with a 0.125 probability of failure, revealed a photogalvanic effect but no significant change in the corrosion rate upon irradiation. Ultraviolet light was found to shift the anodic polarization potential in the negative direction and thus increase the catalytic activity in the joint-electrolyte system prior to failure of the joint. As a consequence, the corrosion resistance of such joints is lowered and their life is shortened, without a change of corrosion mechanism. References 3: all Russian.

2415/12955
CSO: 1842/257

UDC 621.791.763.1:669.715

SELECTION OF QUALITY CRITERION FOR SPOT WELDING OF DIFFERENT ALUMINUM ALLOYS

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 8, Aug 86, pp 3-4

[Article by Engineer D. B. Orlov]

[Abstract] During spot welding of different aluminium alloys of different thicknesses, the axis of symmetry of the cast core is shifted into the zone of maximum temperature. The case of welding of different alloys can be reduced to welding of parts of the same material of different thicknesses, allowing the thickness ratio criterion to be used to evaluate welding quality. This article presents a method for calculation of the adjusted thickness to be used in developing the criterion. References 3: all Russian.

6508/12955
CSO: 1842/7

UDC 621.791.763:669.21.8

MEASUREMENT OF CONDENSOR MICROWELDING MODE PARAMETERS

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 8, Aug 86, pp 5-6

[Article by Engineer S. F. Melnikov, Candidate of Technical Sciences V. P. Bereziyenko and Engineer O. V. Ivanina, Mogilev Machine Building Institute]

[Abstract] Studies were performed of the process of condensor microwelding, showing that the use of a dual-beam type S1-74 oscilloscope to measure current allows deviations to be recorded within limits of 400-500 A, but requires great expenditures of time to process measurement results. The authors' institute has created a device based on conversion of instantaneous values of measured parameters to digital code which is subsequently recorded in random-access memory. The welding current and voltage drop across the electrodes are thus measured and used to determine the power and energy imparted to the welding zone and the resistance of the electrode-electrode circuit. After welding, the instantaneous values of the parameters are displayed on a digital indicator. A block diagram of the device is presented. A crystal-stabilized ADC allows accurate measurement and comparison of time characteristics of the welding parameters. The device can quite accurately measure the electrical parameters of condensor welding, recording deviations of 20-50 A, and their time characteristics.

6508/12955
CSO: 1842/7

UDC 621.791.763.1

SELECTION OF INITIAL COMPRESSIVE FORCE FOR CONTACT WELDING OF PARTS

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 8, Aug 86, pp 4-5

[Article by Engineer M. V. Vasilyev and Engineer V. N. Fomin]

[Abstract] As welding time decreases with increasing welding speed, the initial compressive force must be increased according to the square of the decrease in time, possibly causing plastic deformation of parts before the beginning of application of current. Increasing welding speed requires decreasing the moving mass of automatic welding machines. Decreasing the mass of moving parts of a spring-type drive was found to allow a decrease in the initial compressive force of welding. The mass of the moving parts can be decreased by making those which do not carry current of materials with higher specific strength. References 1: Russian.

6508/12955
CSO: 1842/7

UDC 621.791.763.1

INSTALLATION FOR CONTACT WELDING OF MINIATURE THERMOPILES

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 8, Aug 86, pp 8-9

[Article by Candidate of Technical Sciences E. V. Bumbiyeris and Engineer Ye. S. Lutsuk, Riga Polytechnical Institute imeni A. Ya. Pelshe]

[Abstract] Automatic thermopile manufacture requires production of 300 welds between tiny wires per hour. Experiments have shown that the wires must be first cleaned of oxide film and must be welding with a special power supply. The authors have developed a controlled power supply which, regardless of changes in interelectrode resistance, assures an increase in power at the assigned rate for welding by means of a feedback circuit. A threshold device prevents interelectrode voltage from increasing beyond a set limit. A photograph and drawings of key portions of the device are presented.

6508/12955
CSO: 1842/7

UDC 621.791.763.1.03

NEW SERIES OF RADIAL-TYPE CONTACT SPOT MACHINES

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 8, Aug 86, pp 11-12

[Article by Candidate of Technical Sciences G. I. Zlobin and Engineer G. P. Otke, All-Union Scientific Research, Planning-Design and Technological Institute of Electric Welding Equipment]

[Abstract] A series of radial machines has been developed for contact spot welding, including the MTR-1201, MTR-1701 and MTR-2401, intended to replace the MT-604, MT-810 and MT-1614 machines. The machines have superior technical level, consume less materials in their manufacture, have expanded technical capabilities and are more standardized than the old machines. New welding cycle regulators based on integrated circuits with precise digital readout of time intervals and automatic adjustment as to power factor are used in the new machines. The machines are manufactured in standardized cases and are esthetically designed. The expected annual savings from the use of one new machine will average 1000 rubles. A table of technical characteristics of the machines is presented.

6508/12955
CSO: 1842/7

UDC 621.791.72.621.373.826

LASER WELDING OF ALUMINUM ALLOY WITH LEAD

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 8, Aug 86, pp 12-13

[Article by Doctor of Technical Sciences A. G. Grigoryants, Candidate of Technical Sciences, I. N. Shiganov, Engineer A. V. Kudryavtsev, Moscow Higher Technical School imeni N. E. Bayman and Engineer O. A. Parfenovskaya, Plant Technical School at ZIL Plant]

[Abstract] Welding of aluminum and lead requires very rapid heating and cooling. This article presents a study of welding of these two metals using a laser beam as a concentrated heat source, with an intermediate layer between the metals. The intermediate layer used was tin. Experiments were performed on plates 1-2 mm thick of aluminum alloy type D16 with lead. A tin strip 0.1, 0.3 or 0.5 mm thick was placed in the joint between the aluminum and lead. The plates were first cleaned to a shine, ends ground and pressed together to achieve minimum gap. It was found that laser welding by this method provides a good quality seam. No delamination was observed and the seam contained quasieutectic-type compounds with mean content of 34.40% aluminum 31.59% lead, 31.01% tin. The hardness of the metal at the center of the seam was 48% higher than the hardness of the lead and 43% lower than the hardness of the aluminum alloy. References 3: all Russian.

6508/12955
CSO: 1842/7

UDC 621.791:631.347.4

SURFACING OF ALUMINUM PISTON CHANNELS

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 8, Aug 86, pp 15-16

[Article by Engineer G. N. Vainer, Doctor of Technical Sciences V. I. Chernoivanov, Candidate of Technical Sciences V. Ya. Zusin, All-Union Scientific-Production Association "Remdetal," and Candidate of Technical Sciences A. N. Shalai, "Kievtraktorodetal" Production Association]

[Abstract] A method has been suggested for restoring the channels of tractor pistons by surfacing using the projection between channels as a guide. The method is intended to reduce the amount of new material which is added in the surfacing process, then removed in machining. Diagrams explain the sequence of surfacing operations used to minimize this metal loss.

6508/12955
CSO: 1842/7

UDC 621.791.72.03:621.373.826

PLASAMATRON FOR PLASMA-MECHANICAL WORKING

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 8, Aug 86, pp 27-28

[Article by Candidate of Technical Sciences M. A. Shaterin, Candidate of Technical Sciences M. T. Korotkikh and Engineer V. P. Nechayev, Leningrad Polytechnical Institute imeni M. I. Kalinin]

[Abstract] The laboratory of plasma-mechanical machining of the authors' institute has created a single-arc plasamatron using direct current for plasma-mechanical end milling. Air is used as the heat conductor due to its higher heat content than atomic gases. A gas eddy is used to stabilize the cathode portion of the arc. The air passes through a circular slot formed by the helical surface of the cathode holder. The eddy current which thus arises stabilizes the cathode section of the plasma arc. Water circulates through the inner cavity of the nozzle of the plasamatron, cooling both the nozzle itself and the surrounding structures. A magnetic deflection system is used to increase the dimensions of the heated spots. Introduction of the device at Leningrad's Kirovskiy Zavod Production Association has allowed creation of a new process, plasa-mechanical milling.

6508/12955
CSO: 1842/7

SMELTING IN A LIQUID BATH

Moscow MOSCOW NEWS in English No 22, 8-15 Jun 86, p 10

[Article by Inna Kovalenko; passage enclosed in slantlines printed in boldface]

[Text] /According to Valentin Tsesarsky, sector head of the Heavy Nonferrous Metals Chair at MISA, the new method of obtaining nonferrous metals developed at the Moscow Institute of Steel and Alloys under the guidance of Professor A. Vanyukov, will yield an economic effect estimated at tens of millions of rubles in comparison with the traditional methods, and will raise labor productivity at each installation eight to ten times./

All processes of smelting in nonferrous metallurgy can be broken down into two categories: the traditional, with the use of coke, gas, and electricity; and autogenic processes in which ordinary fuel is no longer needed. The same category includes smelting in a liquid bath, which amounts to a qualitatively new solution in terms of technology and equipment.

Compared with the existing ones, the new method allows a much greater degree of concentrate humidity, which already entails considerable saving in drying. The charge -- enriched ore with sandstone -- must not be reduced to dust, it is enough to break it into small fragments. It is not fortuitous that the new method is called smelting in a liquid bath. Inside the stove the entire mass is in a melted state. An oxygen mixture is supplied under great pressure from the side into the stove, which is very compact. The process of oxidation is accompanied by the release of much heat, which is why the necessary temperature is always maintained inside the melted mass. In terms of productivity such a compact installation can substitute for ten traditional stoves of the same size. Among the merits of the new method is also the high degree of mechanization and automation, which considerably eases the work of the steel smelters.

Many countries have shown interest in the process of smelting in a liquid bath and have sent applications for the purchase of licenses.

12809/12955
CSO: 1842/263

PLANS FOR BOOSTING MOLYBDENUM PRODUCTION IN ARMENIA

Yerevan KOMMUNIST in Russian 26 Jul 86 p 2

[Article by F. Petrosyan, director of the Zangezurskiy Copper-Molybdenum Combine, delegate to the 27th CPSU Congress, under the rubric "On the Course of Technical Progress:" "New Horizons of Gandzasar"; passages enclosed in slantlines printed in boldface]

[Text] The basic Directions for Social-Economic Development of the USSR for 1986-1990 and for the Period to 2000 does not mention the Zangezurskiy Order of Lenin Copper-Molybdenum Combine by name. But the task of re-equipping, rebuilding, and enlarging nonferrous metallurgy enterprises assigned to our republic presents us with a problem of particular importance. The reconstruction which must be done here in the next 10 years is, in its scope, depth, and anticipated effect, unprecedented in the history of Armenia's nonferrous metallurgy.

The ultimate goal of this broad, multiplan program is more the rational, prudent use of the region's molybdenum deposits, with a parallel increase in the production of this most valuable metal. The most practicable way to solve the problem is to switch to mining Gandzasar's leaner ores. But...

To increase production of molybdenum concentrate by 16 percent by 1995, we have to boost ore extraction by 45-50 percent. In other words, /the rates of growth in mining will be three times higher than the growth in the volume of finished product. This disproportion threatens to lead to a contradiction between economy and economics: we will more prudently use the underground stores, but molybdenum production costs will rise./ And this can be avoided only by increasing labor productivity and reducing costs -- by an amount at least commensurate with the discrepancy between the rates at which ore is extracted and refined.

Participating in the 27th CPSU Congress, in the discussing and adopting of a strategy to accelerate the country's social and economic development, I often mentally compared the Party's requirements with the urgent problems of our combine and analyzed them in the light of the aims for all-out intensification of production and introduction of the achievements of scientific-technical progress. Yes, new technology, new equipment, mechanization of operations, and progressive forms of labor organization are specific areas

for applying efforts which will help the enterprise get out of a sticky situation. And they must encompass all elements in the technological cycle. mining, transportation, and concentration of the ore.

Our "leading edge" is the open pit molybdenum mines of Gandzasar. In the 12th Five-Year Plan 110-ton dump trucks and excavators with bucket capacities of 12.5 m^3 will appear there, and 10-m^3 railcars will replace 4-m^3 underground transport cars. All this high-capacity equipment will require the corresponding means to convey the ore to the concentrating mill, which is now done by 5 lines of an overhead cable route.

The point is not just that the cable route simply cannot handle the growing volume of traffic. Rather, it is a labor-intensive, troublesome means of transport, depending on weather, constantly requiring a great deal of repair and maintenance. At least 50 percent of the labor is manual, while 71 percent -- by the end of reconstruction 85 percent -- of the entire combine is mechanized.

The enterprise has already begun constructing a conveyor route. After its completion, ore which has undergone initial processing -- coarse crushing -- will enter a network of four conveyors with a total length of 600 m. Lines will run along an elevated gallery to the left bank of the Okhchi River, then underground to the concentrating mill hoppers. All operations here will be mechanized, offering the opportunity to easily automate the transportation process, and a 5-7 times smaller workforce and less repair and preventive maintenance equipment will be required. A total of 200 service personnel will handle a cycle which now takes 400 workers.

We have also done other promising calculations. Now, as is well known, the Gandzasar deposits are worked in benches 15 m deep. If mechanized explosive preparation is introduced and several other measures are taken, we can switch to mining in 20-m benches. This will greatly reduce specific expenditures per unit of metal extracted.

Major changes are taking place at the Kadzharan Concentrating Mill. Without delving into the details of the measures planned here, which will not be understood by the general reader, I will list only the most promising and important. Switching to operating self-grinding mills instead of traditional ball mills will make it possible to eliminate medium- and fine- crushing shops. This will also eliminate one of the dirtiest and energy-intensive elements from the technological cycle. In addition, new equipment will allow us daily to save up to 7,000 tons of ferrous metal formerly used in the production of ore-crushing balls. Currently operating flotation machines with 3-m^3 chambers are to be replaced by those with 16-m^3 capacity. In this way, we will increase by half the number of flotation machines in existing production areas, while maintaining the present level of electricity consumption and reducing the labor expenditures to concentrate a ton of ore.

As regards technological improvements, the plan developed at the enterprise calls for changes to ensure high autonomy of individual processes. It is

anticipated that this will create stable technological parameters relatively easily adaptable to automatic monitoring and adjustment.

Everything said above pertains to the combine's Kadzharan industrial area, but great things are also happening in Kafan! It is no secret that the reserves of the copper deposits long worked there are running out. However, the rich deposits of polymetal ores discovered nearby are opening new horizons for the enterprise. An additional concentrating mill section, which will go into operation in this five-year plan and will considerably expand the assortment of products produced by the combine, is being built at the regional center.

Of course, all the extensive work to reconstruct, re-equip, and enlarge the combine began and will continue without interrupting the production process and with strict fulfillment of state plans. This imposes a special obligation on our entire collective; it requires maximum mobilization of the strengths and energy of all our members. Such effective levers to increase labor productivity as socialist competition and the switch to the brigade form of labor organization are being brought to the forefront.

In the past five-year plan the combine set up 79 teams, four of which have already switched to complete self-support, and their steady, smooth work has greatly helped the collective fulfill plans and socialist obligations. Now we are considering combining other workers into such brigades and finding new ways to increase furnace operator interest in the final results of their labor.

The 27th Party Congress taught us not only to realistically analyze a situation and clearly define tasks for the future, but also to discover shortcomings and pay attention to factors which could later hinder achievement of maximum efficiency in an effort. Only with this approach can each labor collective be protected from any objective and subjective complications which often keep them from reaching their goals. It is better to talk about them now than to use them in retrospect to conceal failures and interruptions.

Our scientists are a great help in the overall reconstruction of the combine. We are concerned about the unfavorable situation with the automation and mechanization of labor-intensive processes which has developed in nonferrous metallurgy. /Until recently not one organization was engaged in generalizing the experience of related sectors in this country and of similar foreign enterprises in this field./ Not to mention automated technological process control systems such as those which exist, let's say, in chemistry or power engineering -- in our sector, no one has devised a system for the unification and universal introduction of devices and instruments for automated monitoring, adjustment, or control of individual technological processes. Each enterprise at its own responsibility and risk undertakes this independently or seeks a partner among scientific and design organizations. Sometimes this leads to "reinventing the wheel;" sometimes just the opposite -- things are held up due to some minor obstacle. /It appears that it is time to concentrate all this work at a large center which could not only find optimum alternatives for production cycle automation, but also disseminate them to all parts of the sector.

There is another disturbing problem: the more complete use of raw ore. One effective way to do this at the combine is to produce and use pyrite concentrate, which contains sulfur, copper, iron, and other valuable metals. The enterprise long ago developed a technology for producing this concentrate, but pyrite is still thrown out along with final tailings -- only because the planning authorities will not determine a user for these valuable products.

In conclusion, I have to dwell on construction matters. I will not follow the stereotype and accuse the builders of all the mortal sins. Our general contractor, Kadzharanstroy, works quickly and with good quality. If anyone is to be accused, it is the designers and we ourselves. Because design plans and specifications are rarely in proper condition or issued in an amount sufficient for complete use. Quite valid complaints are often lodged against it in terms of both technical level and completeness.

On the other hand, we ourselves often create crises and tense conditions for the builders and put them in a difficult position. Let me present an example. In the 11th Five-Year Plan's first year the combine gave the trust a half million rubles in business; in the second, 1.5 million; and in the third, a whole 10 million. In this five-year plan, a similar picture is expected -- 10 million this year and next, and only 3 million in 1988. It is quite obvious that, given these fluctuations in scope of work, it is difficult for Kadzharanstroy to schedule work, solve the tooling problems of their subdivisions, and take orders from other organizations and departments.

Unfortunately, the installation people handle their obligations even worse than builders. The most recent fact: given a rather wide work front, the Glavspetsmontazhstroy subdivisions for our combine performed a total of 10 percent of the annual volume of installation work for combine facilities. The situation is complicated by the fact that metalwork produced at its enterprises is of very low quality and is even delivered incomplete.

New, broad horizons are opening before the Zangezurskiy Copper-Molybdenum Combine. Our collective is ready to give the country Zangezursk metal in increasing quantities and at lower costs.

12809/12955
CSO: 1842/263

INTRODUCTION OF HIGH-SPEED LEAD SMELTING TECHNOLOGY AT UST-KAMENOGORSK

Moscow PRAVDA in Russian 5 Aug 86 p 2

[Article by staff correspondents T. Yesilbayev and A. Petrushov under the rubric "Across the Land of Soviets": "Toward an Optimum Technology: Obligations under Control;" text in slantlines printed in italics or boldface]

[Text] /"Assimilate progressive raw material smelting technologies at nonferrous metallurgy enterprises" (from socialist obligations of the Kazakh SSR for 1986)/

Ust-Kamenogorsk, Kazakh SSR, 4 Aug--The capital of Rudnyy Altay is called Ust-Kamenogorsk. This city on the Irtysh is inhabited by metallurgists, machine-builders, power engineers, builders, and weavers. But nonferrous metallurgy enterprises play the leading role here. Among them are the country's largest lead-zinc combine imeni V. I. Lenin. Ust-Kamenogorsk lead is recognized as the quality standard at the London Metals Exchange. The enterprise is successfully introducing a new technology for high-speed smelting of raw lead.

"The first results," says Lead Plant Director L. Slobodkin, "confirm the new technology's high efficiency. It makes it possible to raise output of final product without significantly increasing the amount of raw material extracted, materials, or energy."

Here are the numbers. Labor productivity doubled, while coke consumption was cut in half. The production cost of lead dropped 15-20 percent. In addition, sulfur can now be completely removed from the raw material. The new method possesses a low time lag, which makes it possible to instantaneously start and stop the unit. It is simple to maintain, hermetically sealed, and operates without noise.

The essentially new feature of the technology is that the charge is prepared in a liquid medium. This promotes careful mixing of its components and production of a uniform mass. Thus, the entire agglomeration process stage, with its complex dust collection system, mechanical and electrical equipment, buildings, and structures is eliminated. As a result, capital and operating costs are reduced 30-35 percent.

Something else important: unlike the existing technology, high-speed smelting is virtually waste-free. For example, before, sulfur gas, which formed when the charge was roasted, was released in large amounts into the atmosphere to pollute the city's air basin; now, it is used to produce sulfuric acid. The energy from heat released during smelting is also extensively used. It is used to heat premises and thaw concentrates in winter, and for domestic needs. All this made it possible for the plant to do without the services of a TETs.

In a word, the innovation offers broad opportunities for integrated use of raw material and considerable resource savings. But it is appropriate to remember with what difficulty it fought its way to practice. This progressive technology was born 15 years ago in the laboratories of the All-Union Mining-Metallurgy Research Institute for Nonferrous Metals, which is next to the Combine. The first prototype which passed tests at the Institute's experimental plant was also created there. Even then it was clear that the novelty had a great future. However, its introduction into industrial production was fairly protracted -- the turning point was only a year ago, and things have moved more quickly.

"Of course, during this time certain ideas incorporated into the initial design became obsolete," says VNIItsvetmet [All-Union Scientific Research Institute for Nonferrous Metallurgy] Director A. Sychev, doctor of technical sciences. "Therefore, we had to make adjustments even during construction and equipment installation. Now institute specialists are working on creating a unit whose productivity will be twice that of the existing one. Electricity consumption will decrease by a factor of four."

The question arises, won't the promising technology meet the fate of its predecessors? You see, the planning authorities are calling for switching the entire lead plant to the progressive technology only...at the end of this five-year plan.

/First Deputy Chairman of the Kazakh SSR Council of Ministers V. A. Grebenyuk comments:/

"The advantages of the autogenous process are obvious: it essentially changes the technology and improves technical-economic indicators many-fold. This is a real revolution in lead metallurgy; in addition to saving resources and other benefits, it permits comfortable working conditions, and sulfur gas -- the primary polluter of the environment -- is almost completely collected.

"The new technologies in zinc metallurgy convince us of the correctness of the chosen path. In other words, the republic has done a great deal to meet its 1986 obligations to assimilate progressive technologies for smelting raw material at nonferrous metallurgy enterprises. As a result, despite the deterioration of the raw material base, the sector has increased the output of metals and raised the completeness with which raw mineral is used. The new technological processes developed by scientists of the nonferrous metallurgy institute, the USSR Academy of Sciences, and USSR

Minvuz [Ministry of Higher and Secondary Specialized Education] have been patented in several foreign countries.

"And still the speed at which innovations are being introduced cannot satisfy us. The expansion of their application in lead, copper, and zinc production in Kazakhstan alone will bring a total savings of about 50 million rubles a year. What's the obstacle? First -- and we have to state this unequivocally -- the force of inertia. At each stage, we can and must compress time to the minimum, gathering into our hands the material resources and creative forces. We energetically support construction using an organizations own resources which makes it possible to maneuver resources and more quickly accomplish plans to rebuild and re-equip production facilities. The collectives of the republic's leading sector -- nonferrous metallurgy -- are now wisely managing the assets of their development funds for these goals. But they still need help, especially in securing necessary equipment. It is time for USSR Mintyazhmash to organize production of metallurgical units -- for metallurgists to involve themselves in these matters seems senseless to us: it usually takes too much time and effort, and quality suffers."

12809/12955
CSO: 1842/263

UDC 622.725

USE OF CLASSIFICATION BETWEEN STAGES AT TYRNYAUZ BENEFICIATION PLANT

Moscow, TSVETNYYE METALLY in Russian No 8, Aug 86, pp 88-89

[Article by P. S. Goldman, N. Ya. Zhazayev, S. I. Kamarzayeva, R. A. Tekuyev and I. D. Ustinov]

[Abstract] A description is presented of an improvement to the system of classifying ore used at a beneficiation plant, by introducing hydraulic cyclone classification of the subscreen product of the first classification stage. A local automatic density control system was provided at the input of the hydraulic cyclone to prevent plugging. The flow from the cyclone contains up to 30% solids, with the difficult-to-float -10 μm class decreased in the combined class from 16.3 to 14.8%, with a simultaneous decrease in WO_3 content of 18.0 to 13.8%.

6508/12955
CSO: 1842/270

UDC 622.765.4

PRELIMINARY BENEFICIATION OF ZHAYREM ORE IN HEAVY MEDIA

Moscow, TSVETNYYE METALLY in Russian No 8, Aug 86, pp 89-92

[Article by V. D. Tyan, A. A. Rozhnov, G. I. Ivanov, A. Zh. Zhangarayev, G. Ye. Kazneva and D. D. Dzhamakeyev]

[Abstract] Technological studies of Zhayrem-type ore has shown that preliminary beneficiation in heavy media is a promising trend for ores from these deposits. The optimal beneficiation scheme was found to be combined flotation-gravitational beneficiation using recycled water with preliminary beneficiation of the ores in heavy suspensions and subsequent flotation of the beneficiated product. Gravitational beneficiation of monobarite ores on a laboratory installation showed that with a suspension density of 2.8 g/cm^3 and the ore crushed to -50 mm there was clear separation of ore from the light fraction, siliceous clay rock, and the heavy quartz-barite fraction. The light fraction can be utilized as a construction material, inert filler, flux or soil-liming product.

6508/12955
CSO: 1842/270

MISCELLANEOUS

SHORTCOMINGS IN NONFERROUS METALLURGY

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 26 Aug 86 p 2

[Unattributed article: "In the CPSU Central Committee Party Control Committee"; passages enclosed in slantlines printed in boldface]

[Text] /Above serious shortcomings permitted by heads of the USSR Ministry of Nonferrous Metallurgy's Soyuzalyuminiy All-Union Industrial Association in carrying out party and government resolutions to accelerate introduction of progressive technological processes in the aluminum industry./

The CPSU Central Committee's Party Control Committee, having reviewed results of a check, has noted that managers of VPO [All-Union Industrial Association] Soyuzalyuminiy are not fulfilling CPSU Central Committee and USSR Council of Ministers resolutions -- No. 814 of 18 August 1983 "On Measures to Accelerate Scientific-Technical Progress in the National Economy" and No. 968 of 16 October 1985 "On Accelerated Development of the Raw Materials Base and an Increase in the Technical Level of Nonferrous Metallurgy in 1986-1990" -- and are slow at resolving problems of re-equipping and intensifying production, increasing labor productivity and product quality, and improving environmental protection.

The Committee's decision stressed that the aluminum industry is still not using the energy-saving technologies of high-temperature bauxite leaching and fluidized bed aluminum hydroxide calcining which have been developed to fundamentally restructure aluminum oxide production. Aluminum production on the basis of high-power automated electrolyzers with calcined anodes is low. The relative share of worn-out and obsolete equipment at the Bogoslovskiy, Dneprovskiy, and Uralsk Aluminum Plants is high, which leads to over-consumption of fuel and energy resources. Working conditions at these and several other enterprises are harsh, and major emission of harmful substances into the environment is permitted.

The Association and its subordinate All-Union Research and Planning Institute for the Aluminum, Magnesium, and Electrode Industry (VAMI) have tolerated huge miscalculations in creating high-unit-capacity electrolyzers with calcined anodes and automatic technological process control systems (ASU TP "Elektroliz"). Therefore, both delivery of this equipment to new plants under construction and re-equipment of existing plants are being delayed.

Underdesigned electrolyzers were installed at the Tajik and Sayansk Aluminum Plants.

As the check showed, Soyuzalyuminiya managers, as well as those of the Bratsk, Irkutsk, and Krasnoyarsk Plants have long failed to take effective measures to introduce modern automation equipment to service electrolyzers with self-calcining anodes and top feed, which has a deleterious effect on increasing technical-economic indicators and improving working conditions and on more effective environmental protection.

The subsector has systematically failed to fulfill capital investment plans. More than 250 million rubles of industrial construction went unspent in the last five-year plan. Plans for development of the social sphere are chronically unfulfilled, and more than 60,000 square meters of living space and several cultural facilities have not been put into service.

The head of VPO Soyuzalyuminiya, Comrade B. G. Zlokazov, does not make the necessary demands of personnel to accelerate scientific-technical progress and to fundamentally re-equip and intensify production, nor does he take energetic steps to enlarge VAMI's role as the leading institute in the aluminum industry.

VAMI's director, Comrade N. A. Kaluzhskiy, poorly directs the Institute collective's activity in formulating a technical policy for the subsector and in accelerating and expanding the introduction of scientific developments into production.

Former director of the Tajik Aluminum Plant, Comrade S. Makhkambayev permitted violation of State discipline in accepting electrolyzer productive capacities for operation which were delivered with major omissions and without technological process control automation equipment, which has prevented attainment of design indicators up to now. He was also negligent in building residential and public facilities.

The Ministry of Nonferrous Metallurgy's Party Committee does not adequately heighten the responsibility of staff Communists for unconditional fulfillment of Party and State requirements for restructuring work and accelerating the introduction of scientific achievements into production.

The CPSU Central Committee's Party Control Committee has sternly reprimanded Comrade B. G. Zlokazov, head of the USSR Ministry of Nonferrous Metallurgy's Soyuzalyuminiya All-Union Industrial Association and CPSU member, for serious deficiencies in carrying out CPSU Central Committee and USSR Council of Ministers decrees on accelerating scientific-technical progress, for failure to take necessary steps to introduce progressive technological processes at subsector enterprises, and for failure to fulfill assignments to save fuel-energy resources, and has entered it in his personal file. The same punishment was given to CPSU member Comrade N. A. Kaluzhskiy, director of the USSR Ministry of Nonferrous Metallurgy's VAMI for permitting serious deficiencies in elaborating a set of problems in creating automated high-unit-capacity electrolyzers with calcined electrodes and for inadequate

introduction into production of progressive technologies and measures for rational use of fuel-energy resources.

CPSU member Comrade S. Makhkambayev was sternly reprimanded for a negligent attitude in accepting electrolysis productive capacities for operation when director of the Tajik Aluminum Plant and for failure to fulfill plans for building residential and cultural facilities.

The CPSU Central Committee Party Control Committee has pointed out to First Deputy Minister of USSR Nonferrous Metallurgy Comrade L. V. Kozlov the poor control over fulfillment of Ministry orders and measures intended to accelerate introduction of new equipment and technology into the aluminum industry and the low exactingness towards personnel who permit violation of State discipline. His statement that the Ministry will strengthen the management of VPO Soyuzalyuminiya and VAMI and facilitate acceleration of scientific-technical progress in the subsector was taken into consideration.

The USSR Ministry of Nonferrous Metallurgy Party Committee, the Krasnoyarsk party kraykom and Sverdlovsk party obkom, and the Tajikistan Communist Party Central Committee were advised to review the problem of the responsibility of other parties guilty of the shortcomings and violations exposed by the inquiry.

12809/12955
CSO: 1842/263

UDC 669.046:681.32

ANTI-FREQUENCY-SUBSTITUTION FILTERS IN DIGITAL AUTOMATION SYSTEMS

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 7, Jul 86 (manuscript received 16 Jan 86) pp 135-142

[Article by A. A. Yershov, S. M. Kulakov and I. G. Chernysh, Siberian Metallurgical Institute]

[Abstract] Synthesis of an anti-frequency-substitution filter for digital automation systems controlling technological processes in ferrous metallurgy is outlined, the purpose of such a low-pass filter placed before the analog-to-digital converter being to partially suppress high-frequency components in the incoming analog signal and thus also "false" low-frequency components in the outgoing digital signal so that distortions caused by frequency substitution are minimized. First an ideal filter is selected depending on the discretization interval and on the basis of the conditions for absence of frequency substitution. After the necessary properties and spectral characteristics of a linear filter have been established, synthesizing a real filter is formulated as an optimization problem and an algorithm is constructed for its solution on a computer. References 8: 2 Russian, 6 Western (5 in Russian translation).

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CSO: 1842/254

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